UNITED STATES AIR FORCE

611TH AIR SUPPORT GROUP
611TH CIVIL ENGINEER SQUADRON
ELMENDORF AFB, ALASKA

FINAL

REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT

INSTALLATION RESTORATION PROGRAM (IRP) REMEDIAL INVESTIGATION/FEASIBILITY STUDY

KOTZEBUE LONG RANGE
RADAR STATION, ALASKA

JULY 1995

VOLUME I

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Distribution /		
Availability Codes		
Dist	Avail and / or Special	
A-1		

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JULY 1995

VOLUME 1

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This document has been prepared for the United States Air Force by Tetra Tech, Inc. to provide information regarding environmental conditions with respect to possible releases of hazardous substances at the Kotzebue Long Range Radar Station (LRRS), located 4 miles south of Kotzebue, Alaska. As the document relates to actual or possible releases of potentially hazardous substances, its release prior to an Air Force final decision on remedial action may be in the public's interest. The limited objectives of this report and the ongoing nature of the studies at Kotzebue LRRS, along with the evolving knowledge of site conditions and chemical effects on the environment and health, must be considered when evaluating this report, since subsequent facts may become known which may make this report premature or inaccurate. Acceptance of this report in performance of the contract under which it is prepared does not mean that the Air Force adopts the conclusions, recommendations or other views expressed herein, which are those of the contractor only and do not necessarily reflect the official position of the United States Air Force.

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave Blank)

2. REPORT DATE

July 1995

3. REPORT TYPE AND DATES COVERED

4. TITLE AND SUBTITLE

Final Remedial Investigation/Feasibility Study Report,
Installation Restoration Program Remedial Investigation/Feasibility Study,
Kotzebue Long Range Radar Station, Alaska.

5. FUNDING NUMBERS

USAF Contract No.
F33615-90-D-4006

6. AUTHOR(S)

Tetra Tech, Inc.

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Tetra Tech, Inc.
15400 NE 90th Street, Suite 100
Redmond, Washington 98052

8. PERFORMING ORGANIZATION REPORT NUMBER

N/A

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Air Force Center for Environmental Excellence
Environmental Services Office
Environmental Restoration Division (AFCEE/ERD)
Brooks Air Force Base, Texas 78235-5328

10. SPONSORING/MONITORING AGENCY REPORT NUMBER SPONSORING/MONITORING AGENCY REPORT NUMBER

N/A

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for Public Release. Distribution is Unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The purpose of the Remedial Investigation/Feasibility Study Report is to provide a comprehensive description of Kotzebue LRRS, including the installation's operational history and environmental setting; a summary of past IRP investigations at the site; a detailed description of the 1994 remedial investigation; a site conceptual model integrating available site information; and site-specific summaries and recommendations. This document also incorporates a feasibility study which identifies cleanup objectives, evaluates various remedial action alternatives, and recommends appropriate actions to meet cleanup objectives.

14. SUBJECT TERMS

Final Remedial Investigation/Feasiility Study Report

15. NUMBER OF PAGES

376

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

NSN 7540-01-280-5500 Standard Form 298 (Rev 2-89)

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ACRONYM LIST

AAC	Alaskan Air Command
ADEC	Alaska Department of Environmental Conservation
AFB	Air Force Base
AFCEE	Air Force Center for Environmental Excellence
AKA	Also Known As
AOC	Areas(s) of Concern
AQC	Air Quality Control
ARARs	Applicable or Relevant and Appropriate Requirements
ASTM	American Society of Testing and Materials
BETX	Benzene, ethylbenzene, toluene, xylene
BGS	Below Ground Surface
CAA	Clean Air Act
CDLT	Contractor Data Loading Tool
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CLP	Contract Laboratory Program
COPC	Chemicals of Potential Concern
CRP	Community Relations Plan
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
DO	Dissolved Oxygen
DOD	Department of Defense
DQOs	Data Quality Objectives
DROs	Diesel Range Organics
DRS	Drinking Water Standards (AK)
DTIC	Defense Technical Information Center
EPA	Environmental Protection Agency
ES	Engineering - Science, Inc.
ESA	Endangered Species Act
FSP	Field Sampling Plan
GROs	Gasoline Range Organics
IRA	Interim Remedial Action
IRP	Installation Restoration Program
IRPIMS	Installation Restoration Program Information Management System
ITIRs	Informal Technical Information Reports
JSS	Joint Surveillance System

LRRS	Long Range Radar Station
MAR	Minimally Attended Radar
MSL	Mean Sea Level
NCP	National Contingency Plan
NORAD	North American Air Defense Command
NPL	National Priorities List
NTIS	National Technical Information Center
OHSPC	Oil and Hazardous Substance Pollution Control (AK)
OSHA	Occupational Safety and Health Act
PAHs	Polynuclear Aromatic Hydrocarbons
PCBs	Polychlorinated biphenyls
PE	Performance Evaluation
PID	Photo-Ionization Detector
POL	Petroleum, oil, lubricants
PQL	Practical Quantitation Limit
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RAB	Restoration Advisory Board
RBC's	Risk-based Screening Concentrations
RCA	Radio Corporation of America
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
ROCC	Region Operations Control Center
RROs	Residual Range Organics
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SDG	Sample Delivery Group
SOP	Standard Operating Procedure
SVOC	Semi-Volatile Organic Compounds
SWM	Solid Waste Management
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
TSCA	Toxic Substance Control Act
USAF	United States Air Force
USGS	United States Geological Survey
VOC	Volatile Organic Compounds
WACS	White Alice Communications Site

WP	Work Plan
WQS	Water Quality Standards (AK)

EXECUTIVE SUMMARY

The United States Department of the Air Force (USAF) has conducted a remedial investigation/feasibility study (RI/FS) at the Kotzebue Long Range Radar Station (LRRS), Kotzebue, Alaska. The RI/FS was conducted under the authority of the USAF Installation Restoration Program (IRP) and under direction of the Air Force Center for Environmental Excellence (AFCEE), for the 611th Air Support Group, 611th Civil Engineer Squadron.

This document is the RI/FS Report for Kotzebue LRRS, Alaska. It is intended to provide a comprehensive description of Kotzebue LRRS, including the installation's operational history and environmental setting; a summary of past IRP investigations at the site; a detailed description of the 1994 remedial investigation; a site conceptual model integrating available site information; and site-specific summaries and recommendations. This document also incorporates a feasibility study which identifies cleanup objectives, evaluates various remedial action alternatives, and recommends appropriate actions to meet cleanup objectives. Information in this RI/FS Report has been prepared in accordance with the May 1992 version of the Handbook to Support the Installation Restoration Program (IRP) Statements of Work, Volume I-Remedial Investigation/Feasibility Studies (RI/FS) (U.S. Air Force Reprint, 22 May 1992), hereinafter referred to as the *IRP Handbook*. This RI/FS Report is supported by several separate documents prepared for Kotzebue LRRS including:

- Site Characterization Summary (USAF 1995a)
- Baseline Human Health and Ecological Risk Assessment (USAF 1995b)
- Analytical Data ITIR (USAF 1995c)

The Kotzebue LRRS installation is located 26 miles north of the Arctic Circle, approximately 610 miles northwest of Anchorage and 450 miles west-northwest of Fairbanks, Alaska (Figure ES-1). The installation occupies 676 acres of land adjacent to Kotzebue Sound on the Baldwin Peninsula within the Kobuk-Selawik Lowland section of Coastal Central Alaska (Figure ES-2). The LRRS installation, in

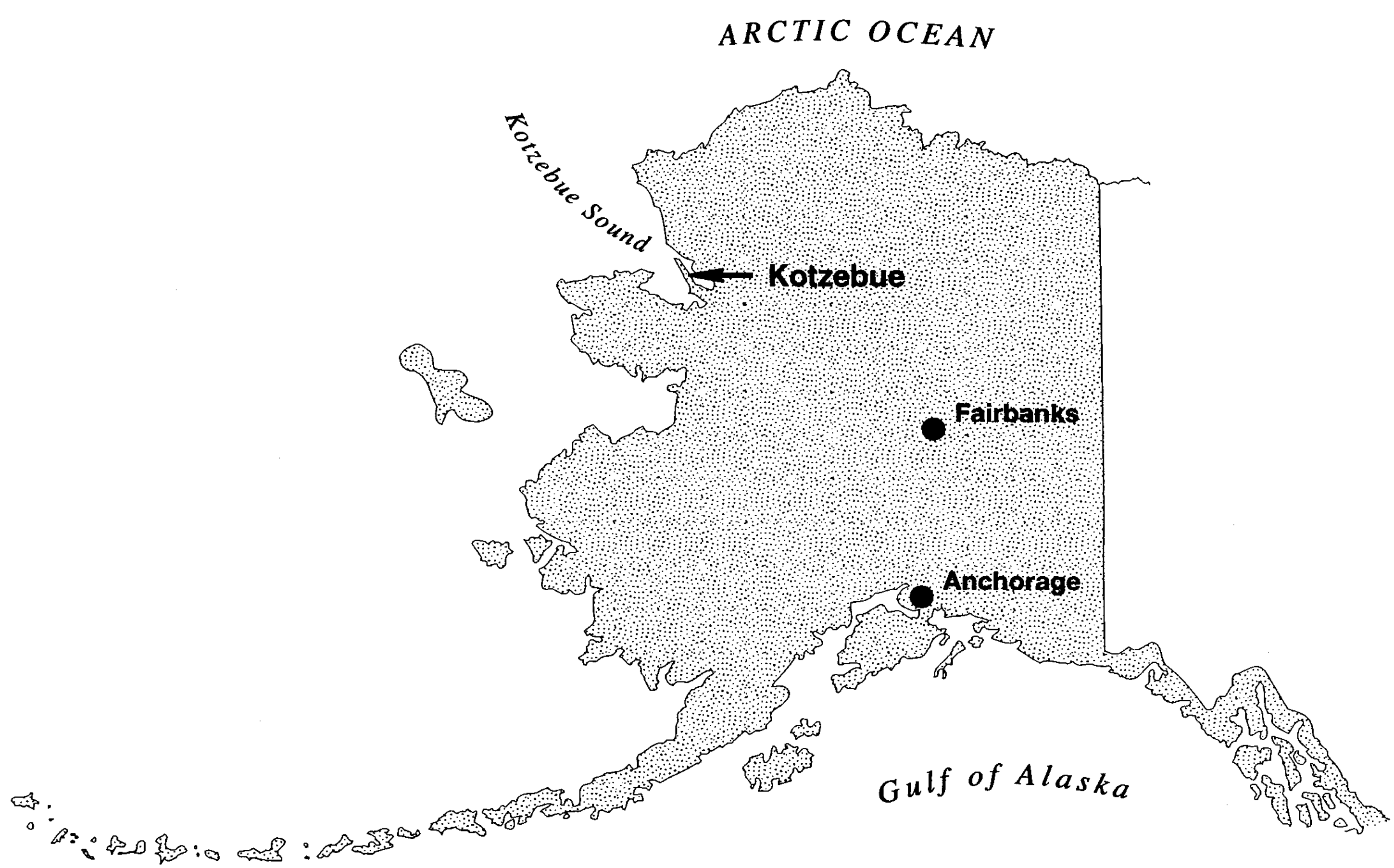

Figure ES-1. Location of Kotzebue, Alaska.

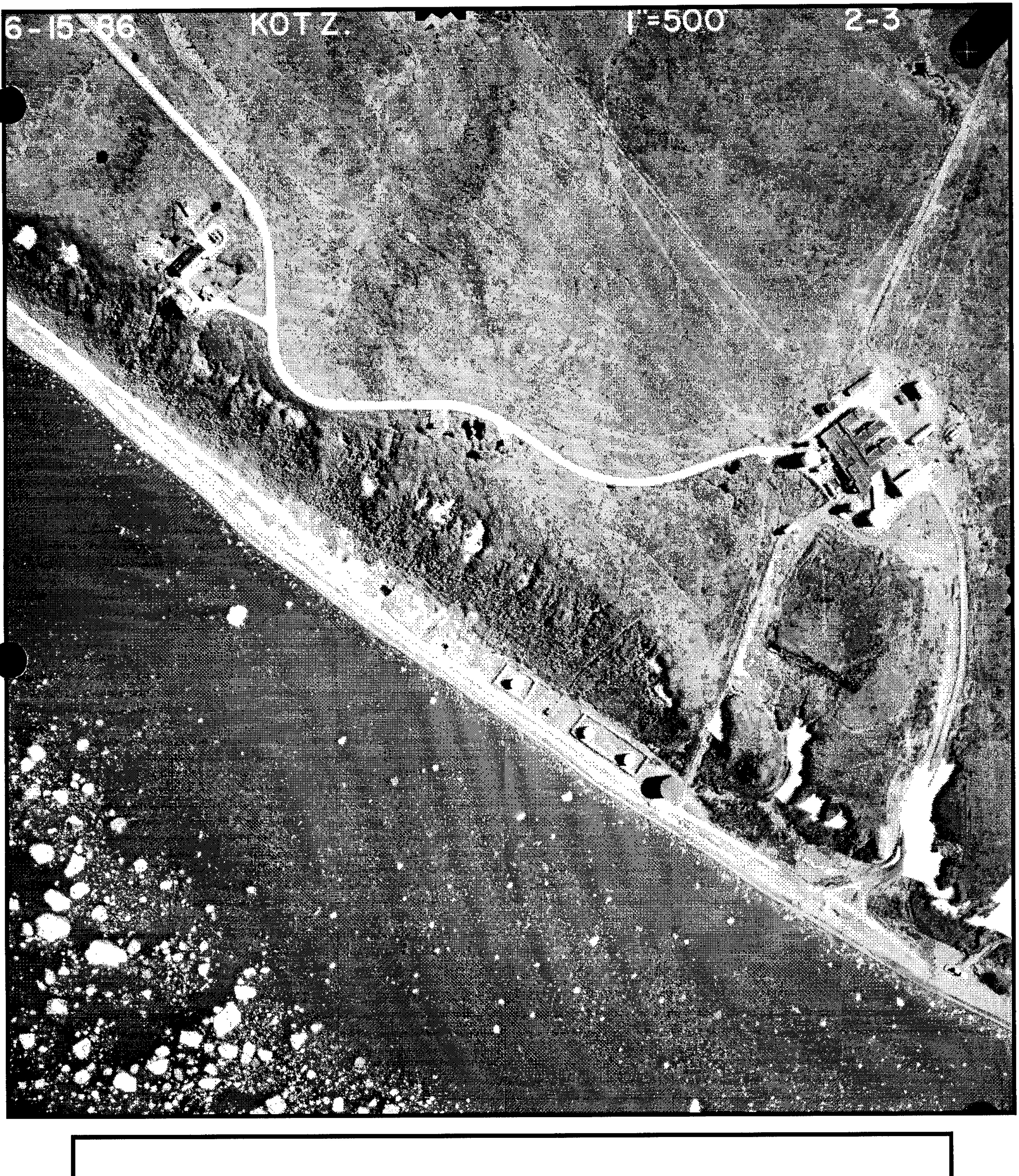

Figure ES2. 1986 Aerial Photograph of Kotzebue LRRS (reproduction).

operation since 1950, operated as a ground-controlled intercept site until 1973, when it was converted to a North American Air Defense Command (NORAD) surveillance station. In 1982, installation of Joint Surveillance System (JSS) equipment enabled radar and beacon data to be transmitted by satellite to the Elmendorf Region Operations Control Center (ROCC), thereby decreasing the number of personnel employed at the site. A Minimally Attended Radar (MAR) system, installed in 1985, enabled deactivation of the site, with the exception of the radome. A single radar maintenance technician is currently housed in the nearby City of Kotzebue. Additional personnel provide maintenance on an as-needed basis. Figure ES-3 provides an illustration of the Kotzebue LRRS facility.

Two distinct environmental settings are associated with the Kotzebue LRRS: 1) the beach environment adjacent to Kotzebue Sound, and 2) the tundra hill and surrounding area (Figure ES-4). Because Kotzebue lies north of the Arctic Circle, the environmental setting is dominated by long cold winters with short daylight hours and a short cool summer growing season with extended periods of daylight.

Petroleum hydrocarbon contamination linked to past installation operations and activities is the primary environmental concern at Kotzebue LRRS. Several investigations have been conducted at Kotzebue LRRS, including a 1985 Phase I records search, 1988 - Stage 1 and 1989-1990 Stage 2 RI/FS programs, beach tank removals, an environmental baseline survey of Navigational Aid Building 101, facility surveys in 1993 and 1994, and a 1994 RI/FS program. A total of 19 sites and 5 areas of concern have been investigated at Kotzebue LRRS (Figure ES-5). Five of the 19 sites identified are considered closed, with concurrence from the Alaska Department of Environmental Conservation (ADEC). Table ES-1 provides a current summary of site status and recommendations for sites and areas of concern investigated at Kotzebue LRRS. Table ES-1 includes USAF site designations, site descriptions, investigation summaries, remaining concerns, and site recommendations.

The general approach during the development of the 1994 Kotzebue IRP RI/FS was to maximize the use of existing data from previous investigations. Available site information was integrated into a site conceptual model used to identify additional data needs, facilitate the selection of remedial designs, and to guide the risk assessment process. Overall project objectives for the Kotzebue LRRS RI/FS include:

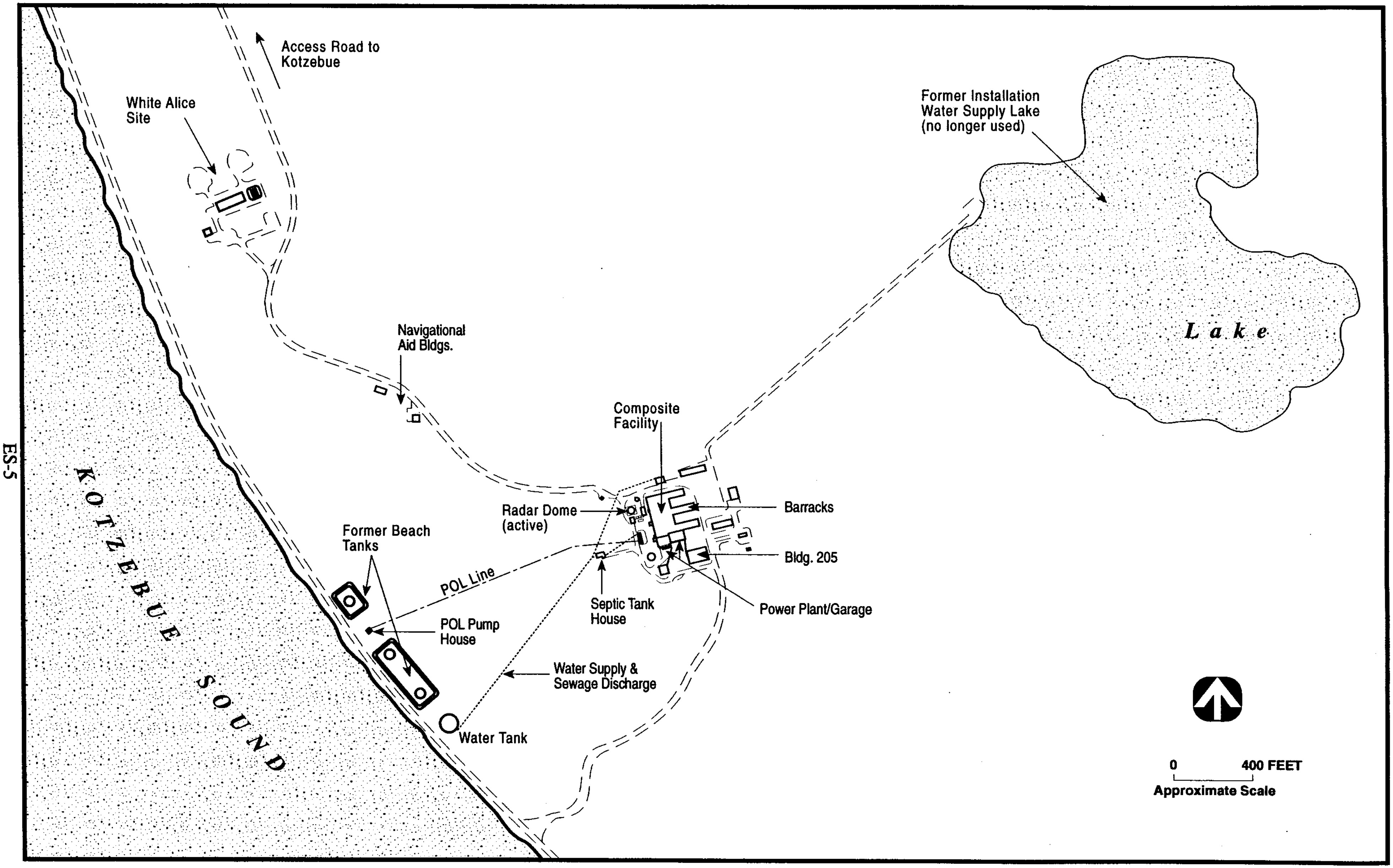

Figure ES-3. Facility Locations at Kotzebue LRRS, Alaska.

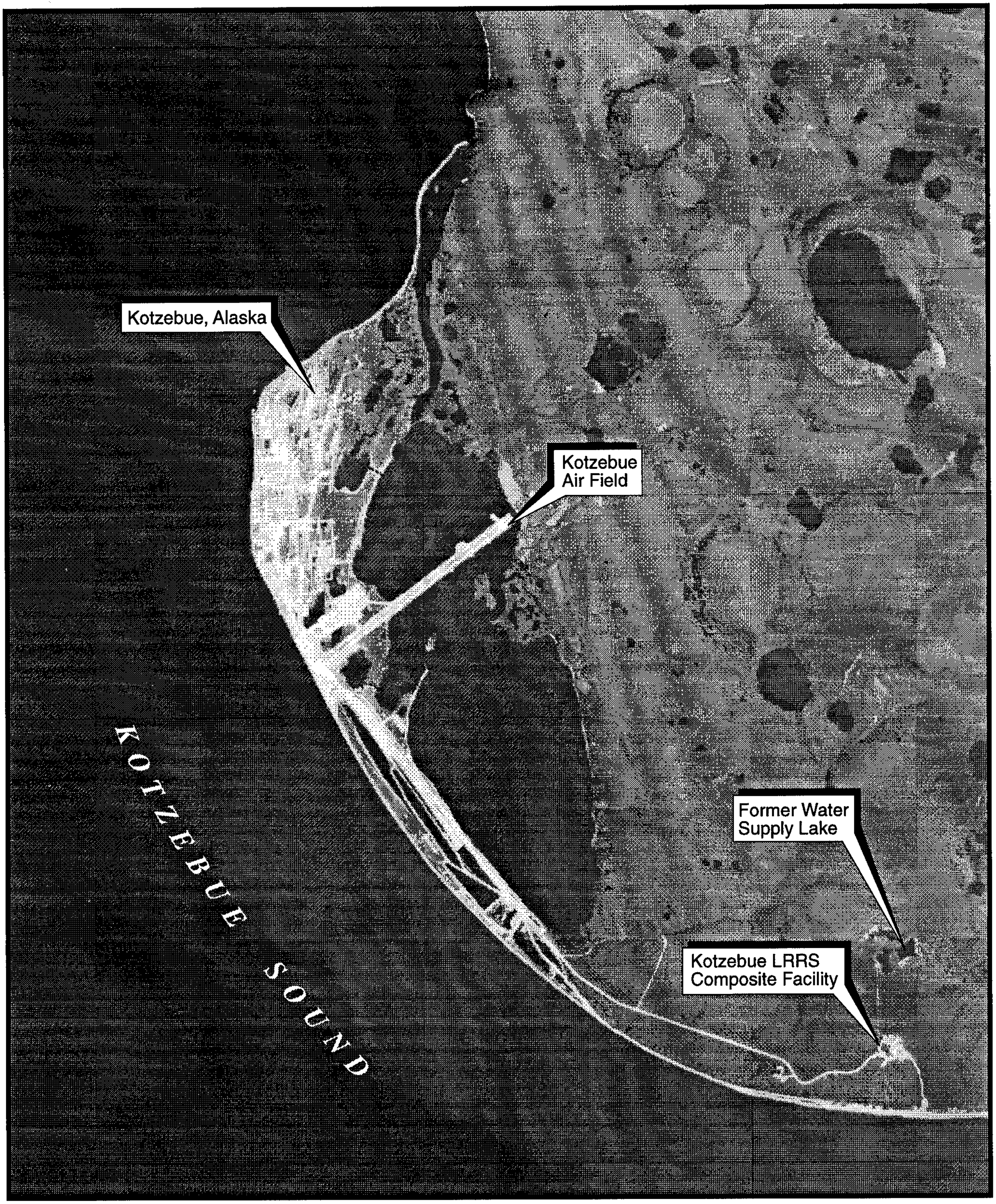

Figure ES4. 1980 Aerial Photograph of Kotzebue, Alaska (reproduction).

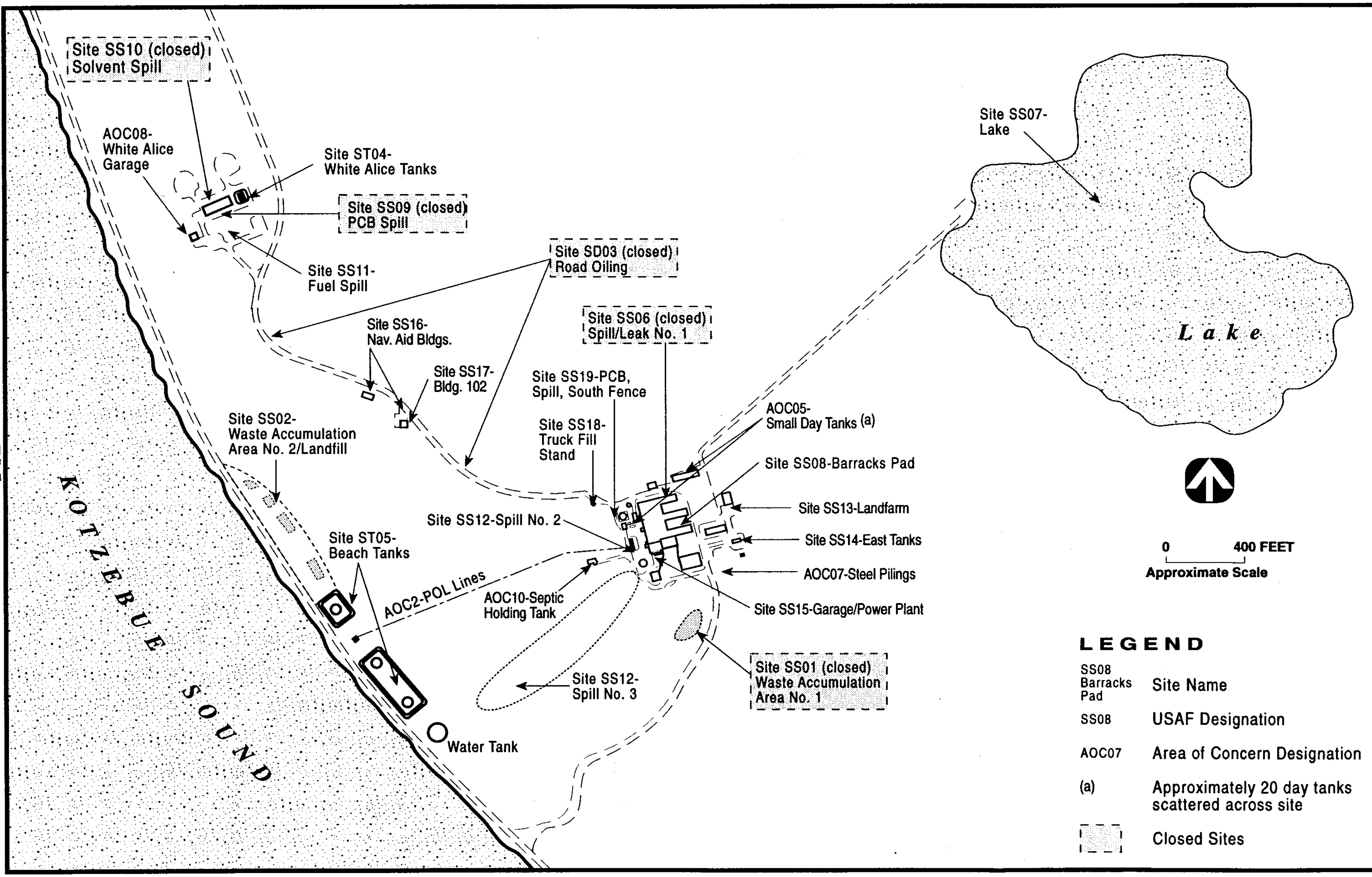

Figure ES-5. Summary of Sites Investigated During Stage 1 RI/FS, Stage 2 RI/FS, or 1994 RI, Kotzebue LRRS, Alaska.

TABLE ES-1. SUMMARY OF SITE STATUS AND RECOMMENDATIONS FOR KOTZEBUE LRRS, ALASKA
(Page 1 of 4)

Site Designation	Site Description	Site Investigation	Remedial Actions Taken	Remaining Site Concerns	Site Recommendations
SS01-Waste Accumulation Area No. 1	The former location of an approximate 80 by 160 foot gravel pad used to store drummed waste oils and/or solvents.	1988 Stage 1 RI/FS; soil sampling.	1989 Excavation and removal of approximately 50 yd^3 of petroleum contaminated fill material.	None	Site closed, with concurrence from ADEC.
SS02-Waste Accumulation Area No. 2/Landfill	The former facility landfill and waste accumulation areas used to store and dispose of wastes at Kotzebue LRRS.	1994 RI; gradiometric survey, monitoring well installation, soil, surface water, and groundwater sampling.	None	Petroleum hydrocarbons (up to 5.5 mg/L) and pesticides detected at relatively low concentrations in shallow near-beach groundwater.	Consider regrading exposed surface debris with soil cover and revegetation of regraded areas. Limited remedial action: Monitoring of downgradient monitoring wells to evaluate potential contaminant migration from the site via groundwater to Kotzebue Sound.
SD03-Road Oiling	Waste oils, spent solvents, and other shop wastes were reportedly used for dust control on the installation's road system.	1988 Stage 1 RI/FS; soil sampling.	None	None	Site closed, with concurrence from ADEC.
ST04-White Alice Tanks (AOC9)	The location of two empty above-ground fuel storage tanks with an estimated capacity of 20,000 gallons each.	1994 RI; soil sampling.	None	Petroleum hydrocarbons (up to 2,900 mg/kg) in gravel fill materials.	Remedial action: excavation and onsite treatment of contaminated fill material .
ST05-Beach Tanks	The former location of three large above-ground fuel storage tanks used to store arctic-grade diesel fuel to heat and power the station.	1988 Stage 1 RI/FS; soil sampling. 1989 Stage 2 RI/FS; soil and groundwater sampling. 1994 RI; soil, groundwater, and seawater sampling, aquifer testing, tidal monitoring, natural attenuation assessment.	1992 Interim remedial action conducted by the USAF including the removal of the three above-ground storage tanks.	Petroleum hydrocarbons in beach sands and gravels (up to 18,000 mg/kg) and in near-beach groundwater (up to 34 mg/L).	Limited remedial action: natural attenuation and long-term groundwater monitoring.
SS06-Spill/Leak No. 1	Reported location of diesel fuel spill which occurred when a pipe coupling failed.	1987 Site Survey	None	None	Site closed, with concurrence from ADEC.
SS07-Lake	The lake formerly used as the facility's water supply source.	1988 Stage 1 RI/FS; surface water and sediment sampling 1994 RI; surface water, sediment, and soil sampling.	None	None	No action needed. Submit closure document to ADEC.
SS08-Barracks Pad	The location of a 25 by 40 foot gravel pad which was reportedly used to store facility chemicals such as solvents, rust inhibitors, and various fluorocarbons.	1988 Stage 1 RI/FS; soil sampling. 1994 RI; soil sampling.	None	Petroleum hydrocarbons (up to 33,000 mg/kg) in gravel fill material.	Remedial action: excavation and onsite treatment of contaminated fill material .

TABLE ES-1. SUMMARY OF SITE STATUS AND RECOMMENDATIONS FOR KOTZEBUE LRRS, ALASKA
(Page 2 of 4)

Site Designation	Site Description	Site Investigation	Remedial Actions Taken	Remaining Site Concerns	Site Recommendations
SS09-PCB Spill	The reported location of a PCB spill which covered an approximate 10 by 10 foot portion of gravel pad.	1988 Stage 1 RI/FS soil sampling.	1989 An estimated 5.3 yd^3 of PCB-contaminated soil was excavated and placed in 55 gallon drums and shipped to DRMO at Elmendorf, AFB, AK.	None	Site closed, with concurrence from ADEC.
SS10-Solvent Spill	The reported location where waste solvents were dumped at the White Alice Site.	1988 Stage 1 RI/FS; soil sampling.	1989 An estimated 9 yd^3 of PCB-contaminated soil was excavated and placed in 55 gallon drums and shipped to DRMO at Elmendorf, AFB, AK	None	Site closed, with concurrence from ADEC.
SS11-Fuel Spill	The reported location of a jet fuel spill which covered an approximate 50 by 60 foot area in native tundra.	1988 Stage 1 RI/FS; soil sampling. 1994 Stage 1 RI/FS; soil, sediment, and surface water sampling.	1989 *In situ* enhanced bioremediation pilot study conducted to reduce concentrations of petroleum hydrocarbons in site soil.	None	No action needed. Submit closure document to ADEC.
SS12-Spills No. 2 and No. 3	The site is comprised of two diesel fuel spill areas which have commingled. Spill No. 2 reportedly occurred in 1979-1980 when a day tank behind the facility's power plant was overfilled covering a 40 by 80 foot area in gravel fill. Spill No. 3 is an estimated 1.5 acre diesel fuel spill located adjacent to, and southwest of, the Composite Facility.	1988 Stage 1 RI/FS; soil and surface water sampling, soil gas survey, water flooding pilot studies. 1994 RI; soil and surface water sampling.	1989 Excavation and removal of approximately 100 yd^3 from Spill No. 2 and 350 yd^3 from Spill No. 3 of petroleum contaminated fill material. 1989-1990 An *in situ* enhanced bioremediation pilot study conducted to reduce petroleum hydrocarbon concentrations in soil.	Petroleum hydrocarbons in soil (up to 53,000 mg/kg) and in ponded surface water (up to 8.8 mg/L).	Remedial action (gravel fill): excavation and onsite treatment of contaminated fill material . Limited remedial action (native tundra): natural attenuation and long-term monitoring.
SS13-Landfarm (AOC1)	A landfarm was constructed during the 1989 Stage 2 RI/FS to remediate approximately 500 yd^3 of petroleum hydrocarbon contaminated soil at Kotzebue LRRS.	1989-1990 Stage 2 RI/FS; intermittent soil sampling to evaluate effectiveness. 1994 RI; soil and surface water sampling.	1989-1990 Approximately 500 yd^3 of petroleum hydrocarbon contaminated soil and fill were excavated from sites and placed in the landfarm cell. Soils were mixed with emulsification, and micronutrient agents.	Petroleum hydrocarbons in landfarm material (up to 5,100 mg/kg), in adjacent native soils (up to 4,800 mg/kg) and in ponded surface water at 2.0 mg/L.	Remedial action (gravel fill): excavation and onsite treatment of contaminated landfarm material. Limited remedial action (native tundra): natural attenuation and long-term monitoring.
SS14-East Tanks (AOC3)	The location of two large (approximately 20,000 gallons each), empty above-ground diesel fuel storage tanks.	1994 RI; soil sampling.	None	Petroleum hydrocarbons (up to 10,000 mg/kg) in gravel fill.	Remedial action: excavation and onsite treatment of petroleum hydrocarbon contaminated fill material.

TABLE ES-1. SUMMARY OF SITE STATUS AND RECOMMENDATIONS FOR KOTZEBUE LRRS, ALASKA

Site Designation	Site Description	Site Investigation	Remedial Actions Taken	Remaining Site Concerns	Site Recommendations
SS15-Garage/Power Plant (AOC4)	The location of the garage and power plant located at the Composite Facility at Kotzebue LRRS.	1994 RI; soil sampling.	None	Petroleum hydrocarbons (up to 10,000 mg/kg) in gravel fill material.	Petroleum hydrocarbon contaminants at Site SS15 have commingled and should be incorporated with Site SS12. Remedial action: excavation and onsite treatment of petroleum hydrocarbon contaminated fill material.
SS16-Navigational Aid Buildings (AOC6)	The location of two navigational aid buildings (Buildings 101 and 102) at Kotzebue LRRS.	1994 RI; soil, sediment, and surface water sampling.	None	Petroleum hydrocarbons (up to 25,000 mg/kg) in gravel fill and (estimated 0.11 mg/L) in ponded surface water.	Remedial action: excavation and onsite treatment of petroleum hydrocarbon contaminated fill material.
SS17-Building 102 (AOC6)	The location of a 6 by 12 foot area of stained soil located in a gravel driveway at the Navigational Aid Building 102	1994 RI; soil sampling.	None	Petroleum hydrocarbons (up to 1,500 mg/kg) in gravel fill.	No further action. (The area of stained soil is currently incorporated in Site SS16.)
SS18-Truck Fill Stand (AOC11)	The location of a truck fill stand consisting of a 10 by 8 foot gravel pad approximately 5 feet thick.	1994 RI; soil sampling.	None	Petroleum hydrocarbons (up to 9,900 mg/kg) in gravel fill and (up to 67,000 mg/kg) in native soils.	Remedial action: excavation and onsite treatment of petroleum hydrocarbon contaminated fill material. Limited remedial action (native tundra): natural attenuation, and long-term monitoring.
SS19-PCB Spill South Fence (AOC12)	The location of a small (100 ft^2) but distinct area of stained gravel fill material west of the active radar dome.	1994 RI; soil sampling.	None	Petroleum hydrocarbons (up to 27,000 mg/kg) in gravel fill.	Remedial action: excavation and onsite treatment of petroleum hydrocarbon contaminated fill material.
AOC2-POL Line	The POL Line is a 2-inch diameter steel pipeline used to transport diesel fuel from the former beach fuel storage tanks to the Composite Facility.	1994 RI; soil sampling.	None	None	No action needed. No closure document required for area of concern.
AOC5-Small Day Tanks	This area of concern represents a number of small day tanks, which were formerly used throughout the installation for heating and equipment operation.	1994 RI; soil sampling.	None	Petroleum hydrocarbons detected in gravel fill and soil above the 1,000 mg/kg ADEC soil target level at nine day tank locations.	Remedial action: excavation and onsite treatment of petroleum hydrocarbon contaminated fill material.

TABLE ES-1. SUMMARY OF SITE STATUS AND RECOMMENDATIONS FOR KOTZEBUE LRRS, ALASKA
(Page 4 of 4)

Site Designation	Site Description	Site Investigation	Remedial Actions Taken	Remaining Site Concerns	Site Recommendations
AOC7-Steel Pilings	The location of several erected steel pilings. The site is the suspected location of the former construction camp established during the construction of the radar facility.	1994 RI; soil sampling.	None	None	No action needed. No closure document required for area of concern.
AOC8-White Alice Garage	The location of a garage facility located at the White Alice site.	1994 RI; soil sampling.	None	Petroleum hydrocarbons (up to 3,500 mg/kg) in soil and PCB Arochlor 1260 (up to 8.4 mg/kg) in fill materials.	Remedial action: excavation and onsite treatment of petroleum hydrocarbon contaminated fill material.
AOC10-Septic Holding Tank	The septic holding tank was the primary treatment for domestic sewage and wastewater at Kotzebue LRRS. Septic tank effluent was discharged to Kotzebue Sound via an outfall line.	1994 RI; septic tank sludge sampling.	None	A sludge sample collected from the base of the septic tank revealed concentrations of volatile and semi-volatile compounds, pesticide and PCBs, and metals, which if released to the environment, may exceed established regulatory and/or risk-based criteria.	Further site assessment is recommended to determine if historical effluent discharge from the septic tank has impacted Kotzebue Sound at or near the outfall location. Removal and/or treatment of sludge material within the spetic holding tank is recommended.

ADEC = Alaska Department of Environmental Conservation.

(AOC9) = Indicates site was previously identified as an area of concern.

- Provide data of sufficient quality and quantity to adequately characterize sites in support of a natural biodegradation evaluation, baseline risk assessment, applicable or relevant and appropriate requirements (ARARs), and a feasibility study.

- Conduct a feasibility study designed to enable the USAF to focus on appropriate remedial actions with consideration to logistical, environmental condition, and climatic limitations.

- Provide appropriate project information and opportunities for community involvement to develop a positive relationship between the USAF and the community of Kotzebue, Alaska.

Federal and state statutes and regulations were reviewed for ARARs that potentially apply to Kotzebue LRRS to guide remedial investigations at Kotzebue LRRS and provide the basis for developing remedial action objectives during feasibility study. ADEC considers sites at Kotzebue LRRS regulated under Water Quality Standards Regulation (18 AAC 70), based on the presence of petroleum hydrocarbons at the site, and the potential for petroleum hydrocarbon migration to surface water and near-beach groundwater adjacent to the facility.

Fourteen sites and five areas of concern were investigated during the 1994 RI as identified below:

- Site SS02-Waste Accumulation Area No.2/Landfill
- Site ST04-White Alice Tanks (AOC9)
- Site ST05-Beach Tanks
- Site SS07-Lake
- Site SS08-Barracks Pad
- Site SS11-Fuel Spill
- Site SS12-Spills No.2 and 3
- Site SS13-Landfarm (AOC1)
- Site SS14-East Tanks (AOC3)
- Site SS15-Garage/Power Plant (AOC4)
- Site SS16-Navigational Aid Buildings (AOC6)

- Site SS17-Building 102 (AOC6)
- Site SS18-Truck Fill Stand (AOC11)
- Site SS19-PCB Spill South Fence (AOC12)
- AOC2-POL Line
- AOC5-Small Day Tanks
- AOC7-Steel Pilings
- AOC8-White Alice Garage
- AOC10-Septic Holding Tank

Figure ES-5 identifies the location of sites and areas of concern investigated during the 1994 RI. A summary of site-specific field activities conducted at Kotzebue LRRS during the 1994 RI is provided in Table ES-2. Sample analyses conducted at sites, areas of concern, and at background stations are summarized in Table ES-3, including the number of samples for each media, sample type, and the number of analytes and analytical methods for each sample. Analytical compounds detected during the 1994 RI are summarized by media in Table ES-4.

A baseline risk assessment was conducted for Kotzebue LRRS to provide an estimate of the potential risk to human health and ecological receptors associated with various exposure scenarios involving site contaminants in the absence of remediation (USAF 1995b). The human health risk assessment is intended to provide a quantitative assessment of the risk to humans and to ecological receptors from exposure to contaminants measured in soil, sediment surface water, and groundwater during the RI at the Kotzebue LRRS conducted in 1994. The risks enumerated in the baseline human health assessment are based upon two types of data: 1) actual measurements of contaminants in the sampled media, and 2) extrapolated estimates of contaminant concentrations into media which were not part of the sampling design, including: air, plants, and land and marine mammals. Extrapolated concentrations were based upon actual detected concentrations in either soil or water at the Kotzebue LRRS site and conservative exposure assumptions (USAF 1995b). Exposure pathways evaluated for potential human and ecological receptors at Kotzebue LRRS are identified in Figures ES-6 and ES-7, respectively. The results of the baseline risk assessment may be used to: 1) support a "No Further Action" decision, 2) prioritize the needs for remediation at various sites, or 3) provide a basis for the quantification of remedial objectives.

TABLE ES-2. SUMMARY OF FIELD ACTIVITIES CONDUCTED DURING 1994 REMEDIAL INVESTIGATION AT KOTZEBUE LRRS, ALASKA

Site Designation	Facilities Inspection	Field Screening	Hand Auger Sampling	Drilling and Sampling	Installing Wells	Groundwater Sampling	Surface Water Sampling	Seawater Sampling	Free Product Assessment	Tidal Influence	Aquifer Testing	Geotechnical Parameters	Gradiometer Survey	Sample Location Surveying
SS02-Waste Area No. 2/Landfill		●		●	●	●			●			●	●	●
ST05-Beach Tanks		●		●	●	●		●	●	●	●	●		●
SS07-Lake		●	●				●							●
SS08-Barracks Pad		●	●											●
SS11-Fuel Spill		●	●											●
SS12-Spills No. 2 and 3		●	●	●	●	●	●					●		●
SS13-Landfarm (AOC1)		●	●											●
AOC2-POL Lines		●	●											●
SS14-East Tanks (AOC3)		●	●											●
SS15-Power Plant/Garage (AOC4)	●	●	●									●		●
AOC5-Small Day Tanks		●	●											●
SS16-Nav. Aid Bldgs. (AOC6)	●	●	●											●
AOC7-Steel Pilings		●	●									●		●
AOC8-White Alice Garage	●	●	●									●		●
ST04-White Alice Tanks (AOC9)		●	●											●
AOC10-Septic Holding Tank	●	●												●
SS18-Truck Fill Stand (AOC11)		●	●											●
SS19-PCB Spill South Fence (AOC12)		●	●											●
Background Characterization		●	●	●	●	●	●	●						

TABLE ES-3. FIELD SAMPLING AND ANALYSES SUMMARY FOR 1994 REMEDIAL INVESTIGATION AT KOTZEBUE LRRS, ALASKA

Site Designation	Media	Number of Samples	Analytes and Methods: Gasoline Range Organics (AK101)	Diesel Range Organics (AK102)	Residual Range Organics (AK102 Extended)	Volatile Organics (8260)	Semivolatile Organics (8270)	Pesticides/PCBs (8081)	Metals (6000, 7000 Series)
SS02-Waste Area No. 2/Landfill	Soil	3		3	1	3	3	3	3
	Groundwater	3	NA[a]	3		3	3	3	6
	Surface Water	1		1		1	1	1	2
ST05-Beach Tanks	Sediment	27		24	1	11	11	3	
	Groundwater	9	NA	9		9	9		NA
	Seawater	3		3		3	3		
SS07-Lake	Sediment	3		3	1	1	3	3	2
	Surface Water	3	NA	3		1	3	3	2
Lake Access	Soil	2						2	
SS08-Barracks Pad	Soil	4	NA	4	1	4	4	4	2
SS11-Fuel Spill	Surface Water	1		1		1	1	1	
	Soil	5	NA	4	NA	4	4	4	NA
	Sediment	1		1		1	1	1	
SS12-Spills No. 2 and 3	Soil	38		38		11	11	10	
	Sediment	2	NA	2	NA	2	2	2	NA
	Surface Water	4		4		4	4	4	
SS13-Landfarm (AOC1)	Soil	6		6	2	3	3	3	2
	Soil	7	NA	7		4	4	4	2
	Surface Water	1		1		1			
AOC2-POL Lines	Soil	3	NA	3	NA	3	3	3	NA
SS14-East Tanks (AOC3)	Soil	7	3	7	NA	3	3	3	NA
SS15-Power Garage/Plant (AOC4)	Soil	8	5	8	1	5	5	5	3
AOC5-Small Day Tanks	Soil	23	NA	23	NA	12	12	12	NA
SS16-Nav. Aid Buildings (AOC6)[b]	Surface Water	1		1		1	1	1	1
	Soil	6	NA	6	2	4	4	4	2
	Sediment	1		1		1	1	1	1
AOC7-Steel Pilings	Soil	3	NA	3	NA	3	3	3	2
AOC8-White Alice Garage	Soil	4	4	4	NA	4	4	4	2
ST04-White Alice Tanks (AOC9)	Soil	4	NA	4	NA	3	3	3	NA
AOC10-Septic Holding Tank	Sediment	1	NA	1	1	1	1	1	1
SS18-Truck Fill Stand (AOC11)	Soil	7	7	7	NA	2	NA	NA	2
SS19-PCB Spill South Fence (AOC12)	Soil	1	NA	1	NA	1	1	1	NA
Background Characterization	Soil	4	3	4		4	4	4	4
	Lake Sediment	3		3	1	3	3	3	3
	Beach Sediment	3		3		3	3	3	3
	Groundwater	1		1		1	1	1	2
	Surface Water	3		3		3	3	3	6
	Sea Water	1		1		1	1		
Total Number of Environmental Samples	Soil	131	22	132	11	73	73	74	24
	Sediment	45		42		23	25	17	10
	Groundwater	13		13		13	13	4	8
	Surface Water	14		14		12	13	13	11
	Seawater	4		4		4	4		
QA/QC Samples	Trip	34	2			32			
	Ambient	12				12			
	Equipment	11	2	11	NA	10	9	5	5
	Duplicate								
	•Soil/Sediment	13		13		8	8	6	1
	•Water	4		4		4	4	1	3

[a] NA indicates no analysis for indicated method(s) were performed.

[b] Site SS17 included in the Characterization of Site SS16.

TABLE ES-4. SUMMARY OF DETECTED COMPOUNDS,
1994 REMEDIAL INVESTIGATION, KOTZEBUE LRRS, ALASKA
(Page 1 of 2)

Analytical Parameter	Environmental Media			
	Soil	Sediment	Surface Water	Groundwater
Volatile Organics				
1,1,2-Trichloro-1,2,2-trifluoroethane	●	●	○	○
Acetone	●	●	●	●
Benzene	●	○	○	●
Carbon Disulfide	○	○	○	●
Chlorobenzene	●	○	○	○
Chloroform	●	○	○	●
cis-1,2-Dichloroethylene	●	○	○	○
Ethylbenzene	●	●	○	●
Methyl Ethyl Ketone (2-butanone)	●	●	●	●
Methylene Chloride	●	●	●	○
Tetrachloroethylene (pce)	●	○	○	○
Toluene	●	●	○	●
Trichloroethylene (tce)	●	○	○	●
Xylenes, total	●	●	○	●
Semivolatile Organics				
1,3-Dichlorobenzene	○	○	●	●
1,4-Dichlorobenzene	●	○	○	○
2-Methylnaphthalene	●	○	○	●
2-Nitroaniline	●	●	○	○
4-Chloroaniline	●	○	○	○
4-Methylphenol	●	●	●	●
4-Nitrophenol	●	●	○	○
Acenaphthene	●	●	○	●
Acenaphthylene	○	○	○	●
Anthracene	●	○	○	○
Benzo(a)anthracene	●	○	○	○
Benzo(a)pyrene	●	○	○	○
Benzo(b)fluoranthene	●	○	○	○
Benzoic Acid	●	●	○	●
bis(2-Ethylhexyl) Phthalate	●	●	●	●
Butylbenzylphthalate	●	○	○	○
Chrysene	●	○	○	○
di-n-butyl Phthalate	●	○	○	○
di-n-Octylphthalate	○	○	○	●
Dibenzofuran	●	○	○	●
Dimethyl Phthalate	●	○	○	○
Fluoranthene	●	○	○	○
Fluorene	●	○	○	●
Isophorone	●	●	●	○

TABLE ES-4. SUMMARY OF DETECTED COMPOUNDS,
1994 REMEDIAL INVESTIGATION, KOTZEBUE LRRS, ALASKA
Page 2 of 2

Analytical Parameter	Environmental Media			
	Soil	Sediment	Surface Water	Groundwater
Semivolatile Organics (Cont.)				
Naphthalene	●	○	○	●
Phenanthrene	●	○	○	●
Phenol	●	○	○	●
Pyrene	●	○	○	○
Pesticides/PCBs				
4,4'-DDD	●	●	●	●
4,4'-DDE	●	●	●	●
4,4'-DDT	●	●	●	●
Aldrin	●	●	●	○
alpha BHC	●	●	●	○
alpha-Chlordane	●	●	○	○
Arochlor 1254	●	●	○	○
Arochlor 1260	●	●	○	○
beta BHC	●	○	●	○
delta BHC	●	●	●	○
Dieldrin	●	●	●	○
Endosulfan I	●	○	○	○
Endosulfan Sulfate	○	○	●	○
Endrin	●	●	○	○
Endrin Aldehyde	●	○	○	○
gamma BHC (Lindane)	●	●	○	○
gamma-Chlordane	●	●	○	○
Heptachlor	●	○	●	○
Heptachlor Epoxide	●	●	●	○
Methoxychlor	●	●	○	○
Metals[a]				
Barium	○	○	●	○
Calcium	●	●	●	○
Iron	○	○	●	●
Lead	●	●	○	○
Magnesium	○	○	●	○
Manganese	○	○	●	●
Potassium	○	○	●	●
Sodium	○	○	●	○
Zinc	○	●		○
Petroleum Hydrocarbons	●	●	●	●

○ = Not detected. ● = Detected.

[a] Metals Analysis: Inorganic compounds listed are those compounds detected at or above three times their mean background concentrations.

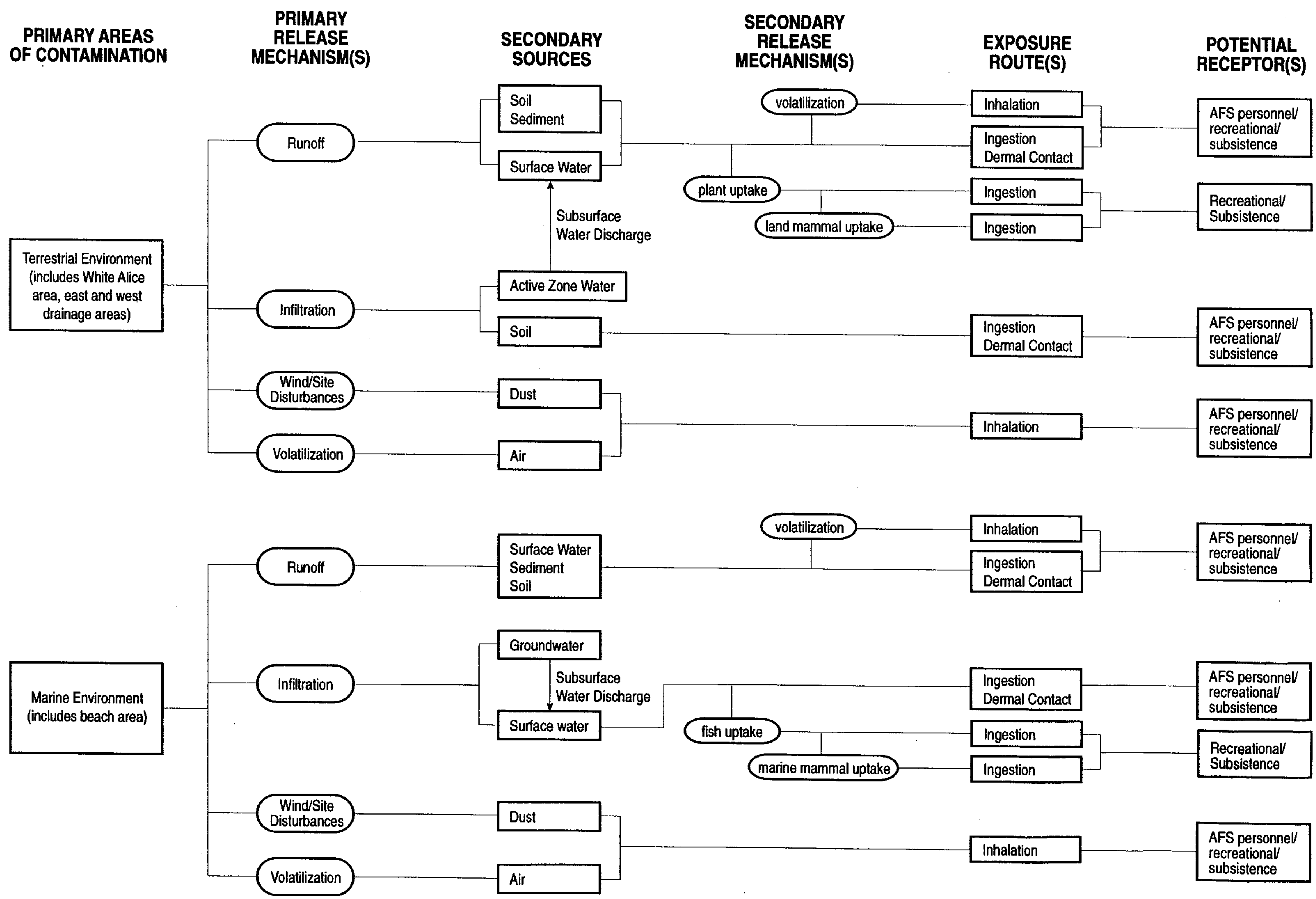

Figure ES-6. Human Health Exposure Pathways Evaluated for Kotzebue LRRS, Alaska.

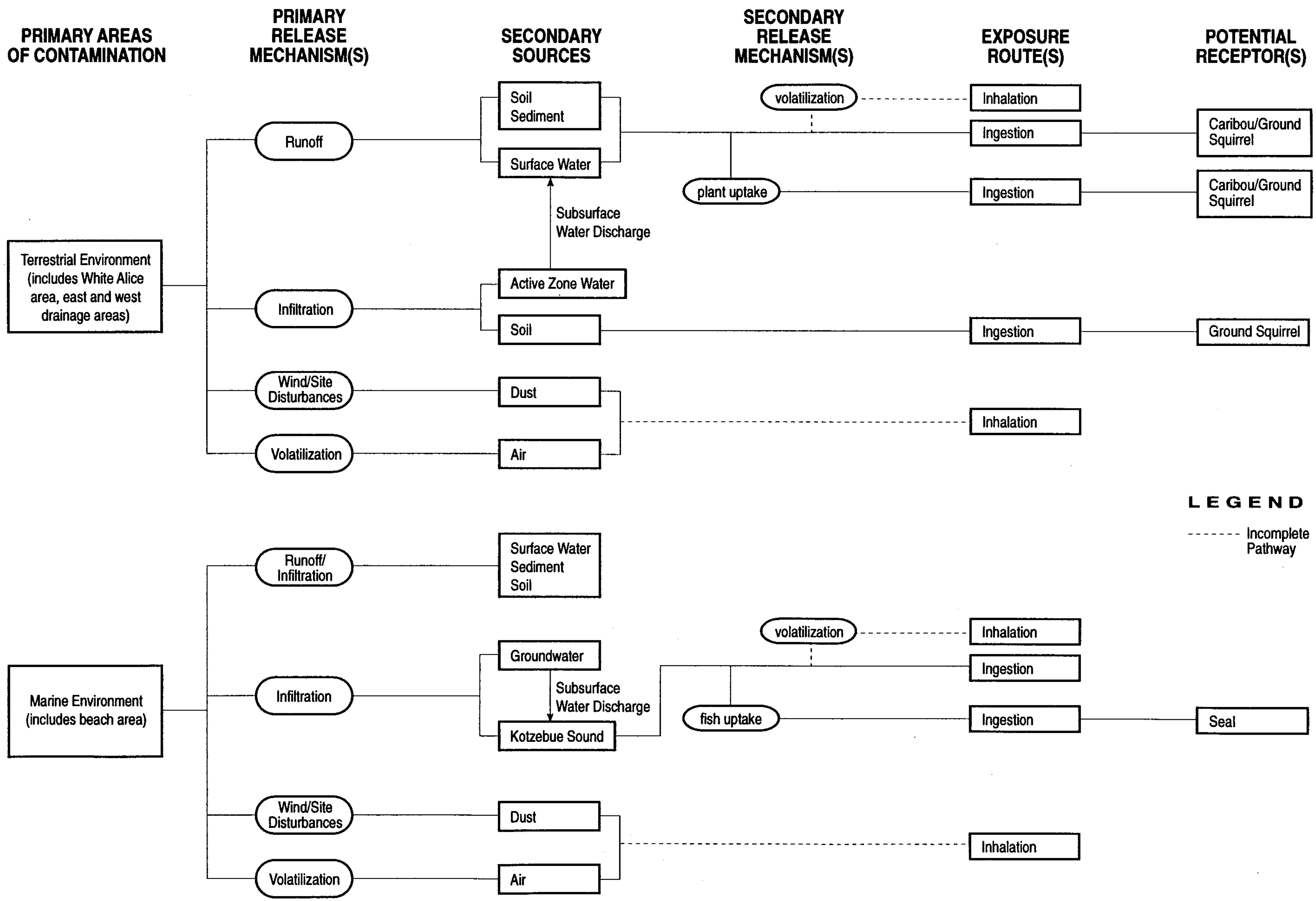

Figure ES-7. Ecological Exposure Pathways Evaluated for Kotzebue LRRS, Alaska.

A feasibility study was conducted for Kotzebue LRRS to identify cleanup objectives, evaluate various remedial action alternatives, and recommend appropriate actions to meet cleanup objectives. Due to the remote location of Kotzebue, Alaska, appropriate remedial actions were evaluated with consideration of logistical, environmental, and climatic limitations. The native tundra environment at Kotzebue LRRS is fragile, and remedial actions that do not cause damage to tundra and underlying permafrost were favored.

Remedial action objectives for soil and sediment include consideration of three primary lithologic types that characterize Kotzebue LRRS: beach sands and gravels, native soils associated with the tundra hill and surrounding area, and fill material used for roads and facility foundations. Near-beach groundwater and surface water were also evaluated during development of remedial action objectives. General response action and associated remedial technologies selected to address contaminated soils, sediments, surface water, and near-beach groundwater are identified in Table ES-5. Five remedial action alternatives were developed to address remaining environmental concerns at Kotzebue LRRS (Table ES-6).

A detailed and comparative analyses of five selected alternatives were conducted to provide the basis for remedy selection, detailed remedial design, and remedial action. Site specific recommendations based on an evaluation of ARARs, risk-based criteria, and appropriate remedial alternatives are provided in Table ES-1.

A primary objective of the USAF is to provide appropriate project information and opportunities for community involvement throughout the environmental investigation and cleanup process at Kotzebue LRRS. The City of Kotzebue has teamed with the USAF and other agencies to establish a Restoration Advisory Board (RAB). The concept of forming a RAB was initiated by the USAF to involve the local communities in the process of environmental awareness and prioritizing cleanup. The board will serve as a forum for discussion and information exchange between the community and the federal/state agencies who are guiding the restoration of the Kotzebue LRRS. The responsibilities of the RAB include addressing such issues as cleanup goals, setting priorities, reviewing plans and documents, and conducting regular meetings that are open to the public. The RAB compliments other community involvement initiatives that have been established, and provides an additional means of information gathering and exchange.

TABLE ES-5. GENERAL RESPONSE ACTIONS AND ASSOCIATED TECHNOLOGIES TO ADDRESS CONTAMINATED SOIL, GROUNDWATER, AND SURFACE WATER AT KOTZEBUE LRRS, ALASKA

General Response Action	Remedial Technologies for Soil	Remedial Technologies for Groundwater/Surface Water
NO ACTION	Consideration is required by the NCP	Consideration is required by the NCP
LIMITED ACTION	- Site controls - Institutional controls - Natural attenuation - Long-term monitoring	- Site control - Institutional controls - Natural attenuation - Long-term monitoring
CONTAINMENT	- Capping - Surface controls	
EXTRACTION	- Excavation	
EX SITU TREATMENT	PHYSICAL/CHEMICAL TREATMENT - Soil washing - Solidification/stabilization/fixation - Hot air vapor extraction BIOLOGICAL TREATMENT - Landfarming - Enhanced biodegradation - Slurry-phase biodegradation THERMAL TREATMENT - Low temperature thermal stripping - High temperature thermal treatment	
IN SITU TREATMENT	PHYSICAL/CHEMICAL TREATMENT - Vacuum vapor extraction - Soil flushing - Chemical reduction/oxidation - Fixation BIOLOGICAL TREATMENT - Enhanced biodegradation - Bioventing THERMAL TREATMENT - Thermally enhanced soil vapor extraction	BIOLOGICAL TREATMENT - Enhanced Biodegradation
OFFSITE TREATMENT	- Landfill - Incineration - Beneficial Reuse	

TABLE ES-6. REMEDIAL ACTION ALTERNATIVES ASSEMBLED FOR SOILS, SURFACE WATER, AND GROUNDWATER AT KOTZEBUE LRRS
Soils/Sediment
Fill Materials
Alternative 1. No Action Alternative 2. Access Restriction, Natural Attenuation/Monitoring Alternative 3. *In Situ* Enhanced Biodegradation Alternative 4. Excavation, Onsite Treatment by Thermal Washing Alternative 5. Excavation, Onsite Enhanced Biodegradation
Native Soils
Alternative 1. No Action Alternative 2. Access Restriction, Natural Attenuation/Monitoring Alternative 3. *In Situ* Enhanced Biodegradation
Beach Sands and Gravels
Alternative 1. No Action Alternative 2. Access Restriction, Natural Attenuation/Monitoring Alternative 3. *In Situ* Enhanced Biodegradation Alternative 4. Excavation, Onsite Treatment by Thermal Washing Alternative 5. Excavation, Onsite Enhanced Biodegradation
Near-Beach Groundwater/Surface Water
Alternative 1. No Action Alternative 2. Access Restriction, Natural Attenuation/Monitoring

1.0 INTRODUCTION

The United States Department of the Air Force (USAF) has conducted a a remedial investigation/feasibility study (RI/FS) at the Kotzebue Long Range Radar Station (LRRS), Kotzebue, Alaska. The RI/FS was conducted under the authority of the USAF Installation Restoration Program (IRP) and under direction of the Air Force Center for Environmental Excellence (AFCEE), for the 611th Air Support Group, 611th Civil Engineer Squadron.

The objectives of the IRP are to: 1) identify and evaluate sites where contamination may be present on Department of Defense (DOD) property because of past hazardous waste disposal practices or spills, 2) control the migration of hazardous contaminants, and 3) control health hazards or hazards to the environment that may result from past DOD operations. Requirements of the IRP were developed to ensure DOD compliance with federal laws such as the National Oil and Hazardous Substances Pollution Contingency Plan (NCP); Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); and Superfund Amendments and Reauthorization Act (SARA). The IRP is DOD's primary mechanism for response actions on USAF installations affected by the provisions of SARA. In November 1986, in response to SARA and other Environmental Protection Agency (EPA) guidance, the USAF modified the IRP to provide for an RI/FS program. The IRP is designed so that the RI and FS are conducted as parallel activities, rather than as serial activities. The program now includes the determination of Applicable or Relevant and Appropriate Requirements (ARARs), identification and screening of technologies, and development of remedial alternatives.

Kotzebue LRRS is not a National Priorities List (NPL) site; however, the USAF has conducted IRP RI/FS activities at the site to ensure comprehensive site characterization and the develop of environmental restoration solutions that provide for the protection of human health and the environment, meet the requirements of ARARs, are technically feasible to implement at the site, and are cost effective.

1.1 PURPOSE OF THIS DOCUMENT

This document is the RI/FS Report for Kotzebue LRRS, Alaska. It is intended to provide a comprehensive description of Kotzebue LRRS, including the installation's operational history and environmental setting; a summary of past IRP investigations at the site; a detailed description of the 1994 remedial investigation; a site conceptual model integrating available site information; and site-specific summaries and recommendations. This document also incorporates a feasibility study which identifies cleanup objectives, evaluates various remedial action alternatives, and recommends appropriate actions to meet cleanup objectives. Information in this RI/FS Report has been prepared in accordance with the May 1992 version of the Handbook to Support the Installation Restoration Program (IRP) Statements of Work, Volume I-Remedial Investigation/Feasibility Studies (RI/FS) (U.S. Air Force Reprint, 22 May 1992), hereinafter referred to as the *IRP Handbook*. This RI/FS Report is supported by several separate documents prepared for Kotzebue LRRS including:

- Site Characterization Summary (USAF 1995a)
- Baseline Human Health and Ecological Risk Assessment (USAF 1995b)
- Analytical Data ITIR (USAF 1995c)

1.2 INSTALLATION DESCRIPTION

The Kotzebue LRRS installation is located 26 miles north of the Arctic Circle, approximately 610 miles northwest of Anchorage and 450 miles west-northwest of Fairbanks, Alaska (Figure 1-1). The installation occupies 676 acres of land adjacent to Kotzebue Sound on the Baldwin Peninsula within the Kobuk-Selawik Lowland section of Coastal Central Alaska (Figure 1-2). The LRRS installation, in operation since 1950, operated as a ground-controlled intercept site until 1973, when it was converted to a North American Air Defense Command (NORAD) surveillance station. In 1982, installation of Joint Surveillance System (JSS) equipment enabled radar and beacon data to be transmitted by satellite to the Elmendorf Region Operations Control Center (ROCC), thereby decreasing the number of personnel employed at the site. A Minimally Attended Radar (MAR) system, installed in 1985, enabled deacti-

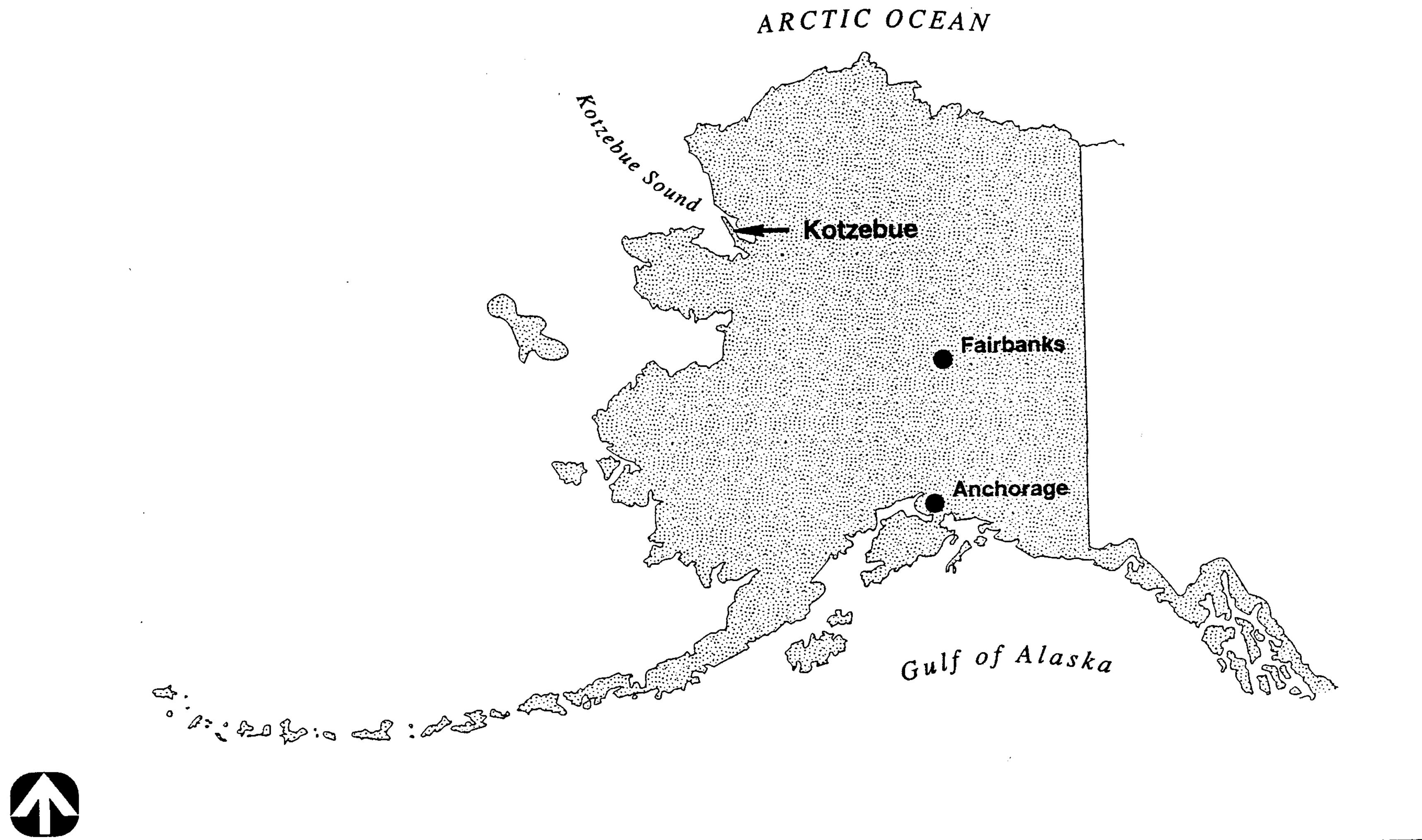

Figure 1-1. Location of Kotzebue, Alaska.

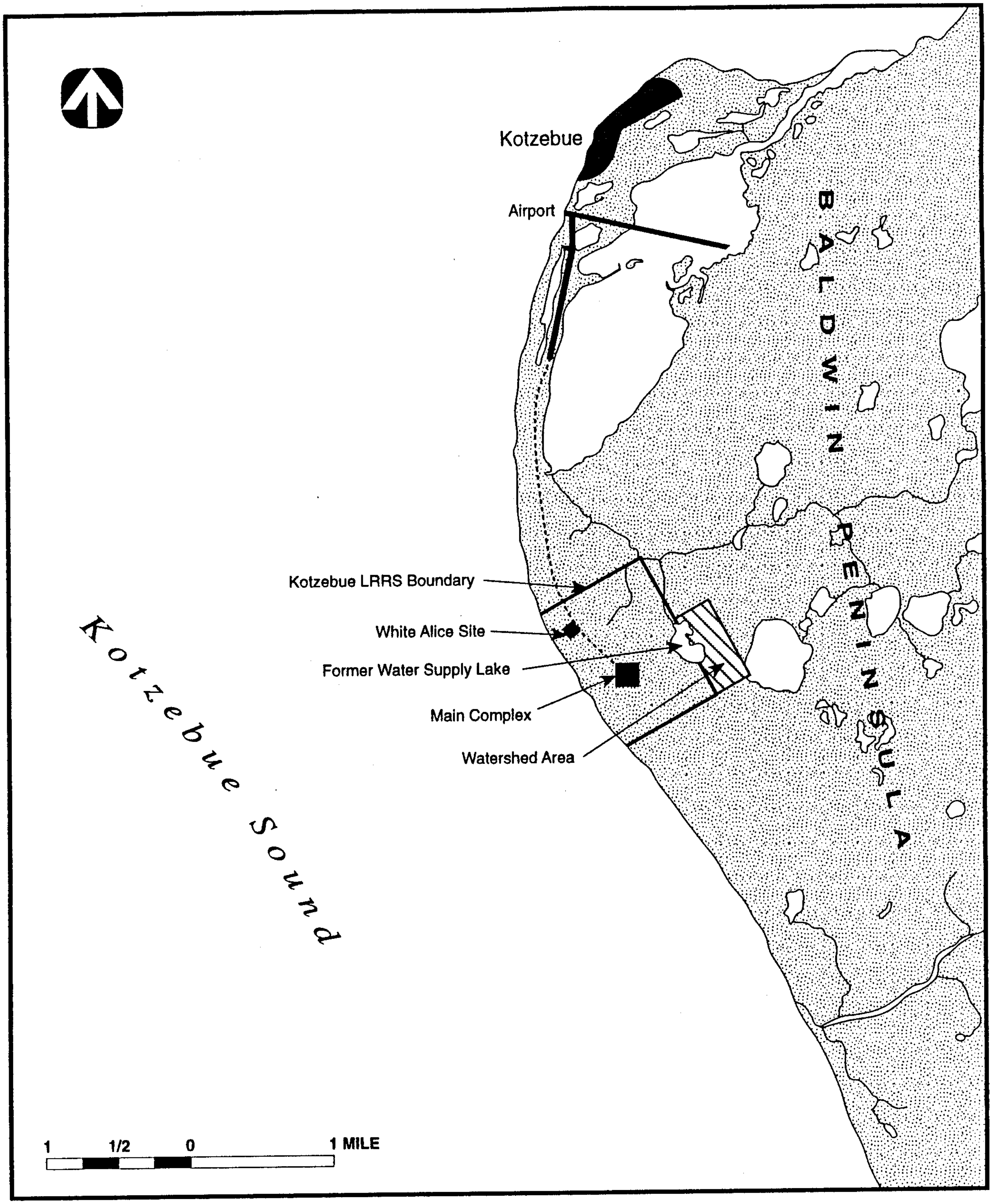

Figure 1-2. Location of the Kotzebue Long Range Radar Station (LRRS), Alaska.

vation of the site, with the exception of the radome. One radar maintenance technician (housed in the nearby City of Kotzebue) currently services the active radar dome. Additional personnel provide maintenance on an as-needed basis. Figure 1-3 provides an illustration of the Kotzebue LRRS facility.

Past operations at Kotzebue LRRS, such as radar and vehicle shop maintenance, generated waste oils, spent solvents, and other wastes (USAF 1990a). Some waste oils were used for ground application (dust control) on roads. A waste accumulation area and installation landfill, both located adjacent to Kotzebue Sound, were used to store and dispose of facility wastes. Potential contaminants associated with base operations include waste oil, fuels, solvents, polychlorinated biphenyls (PCBs), herbicides, and pesticides. In 1972, the waste accumulation area was closed, and in 1974 the landfill was closed. The waste accumulation area and landfill were cleaned and regraded, and drummed wastes were removed from the installation in 1975. Fuel management at Kotzebue LRRS resulted in leaks and spills. Diesel fuel was stored in large above-ground storage tanks located adjacent to Kotzebue Sound. These tanks provided fuel to smaller fuel tanks located adjacent to the Composite Facility. The beach fuel storage tanks were removed in 1992. The smaller fuel tanks are still in place, but were inspected and emptied of any residual product in 1993.

1.3 REPORT ORGANIZATION

Section 2.0 provides an overview of the environmental setting. Section 3.0 describes past IRP investigation activities conducted at Kotzebue LRRS. Section 4.0 provides a comprehensive review of the 1994 Remedial Investigation. This section describes project objectives, ARARs, remedial investigation activities, and remedial investigation results. Section 5.0 provides a site conceptual model developed by integrating available site information. Section 6.0 provides a feasibility study for Kotzebue LRRS based on information collected during the 1994 RI. This section identifies recommended cleanup objectives, evaluates various remedial action alternatives, and recommends appropriate actions to meet the cleanup objectives. Section 7.0 provides individual summaries on a site-by-site basis, including site description, IRP investigation activities, remaining site concerns, and site recommendations for each of the 24 sites and areas of concern at Kotzebue LRRS. Section 8.0 provides a status of community involvement. Section 9.0 includes all references cited in the document.

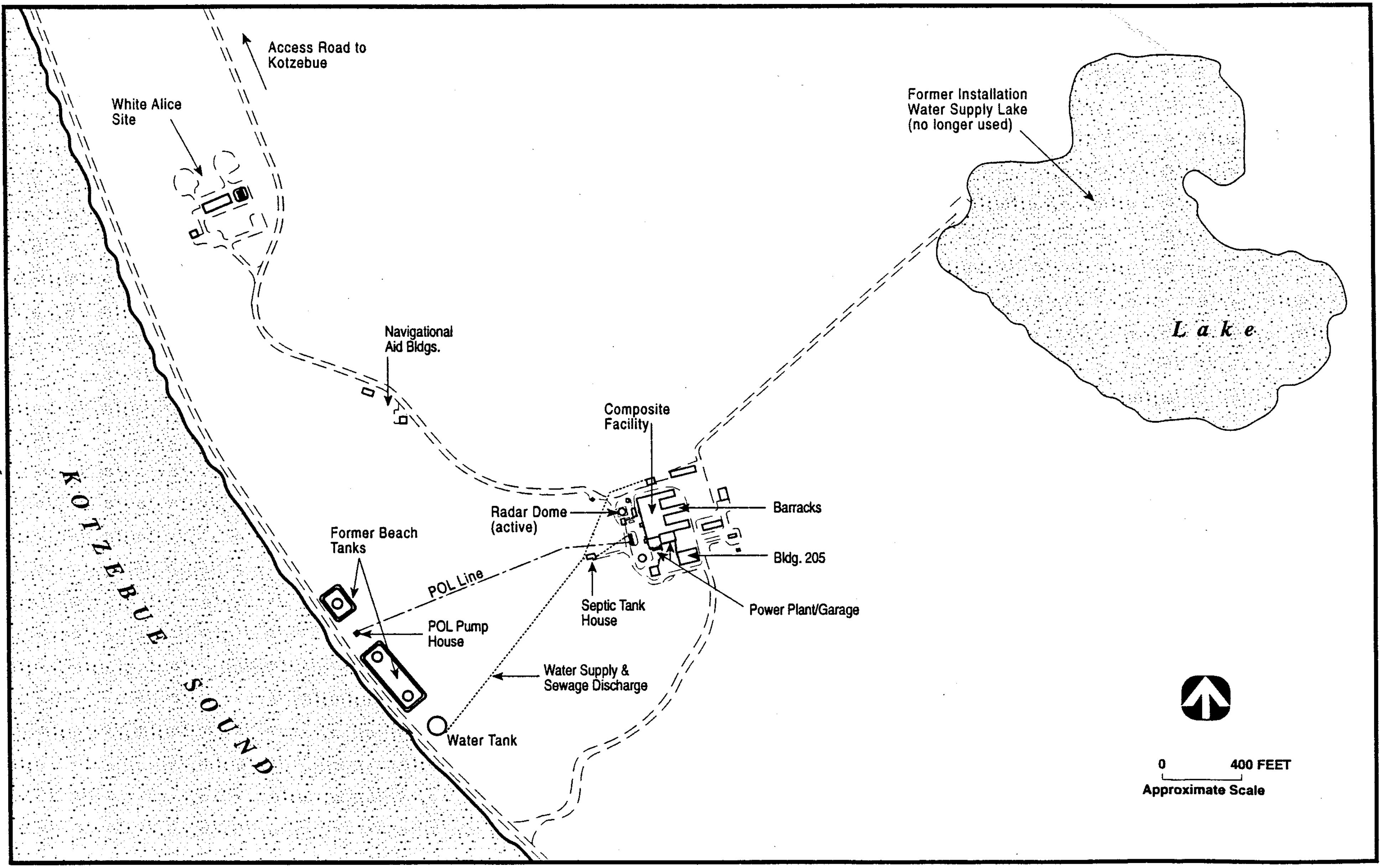

Figure 1-3. Facility Locations at Kotzebue LRRS, Alaska.

2.0 ENVIRONMENTAL SETTING

Two distinct environmental settings are associated with the Kotzebue LRRS: 1) the beach environment adjacent to Kotzebue Sound, and 2) the tundra hill and surrounding area. Because Kotzebue lies above the Arctic Circle, the environmental setting is dominated by long cold winters with short daylight hours and a short cool summer growing season with extended periods of daylight. The environmental setting of Kotzebue Sound and the Baldwin Peninsula is discussed in regards to physiography, climate, geologic/hydrogeologic characteristics, surface water, oceanography, biological habitats, demographics, and land use.

2.1 PHYSIOGRAPHY

Kotzebue LRRS is located on the Baldwin Peninsula, a marine spit that extends into Kotzebue Sound. The Baldwin Peninsula lies within the Kobuk-Selawik Lowland section of Coastal Western Alaska (see Figure 1-1). This region is characterized by broad river floodplains and lowlands, forming deltas along their seaward margins. The ground surface is composed of moist tundra vegetation, with wet silts and permafrost underlying most of the area (USAF 1990a). Figure 2-1 is a reproduction of a 1986 aerial photograph of Kotzebue LRRS showing general site features. Figure 2-2 is a reproduction of a 1980 aerial photograph of the Kotzebue area, showing the City of Kotzebue in relation to the site.

The maximum topographic relief at Kotzebue LRRS is the crest of the tundra hill (elevation of approximately 155 ft above mean sea level) which extends from the Composite Facility toward Kotzebue Sound. Flooding is not known to have been a problem in the area, although the U.S. Army Corps of Engineers indicated that the site is located in a coastal flood hazard zone as designated by the Federal Insurance Administration (USAF 1990a). Periodic flooding of local beaches and adjacent low-lying areas occurs when high tides and high shoreward winds coincide. However, with the exception of two sites located along the beach area adjacent to Kotzebue Sound, all sites at Kotzebue LRRS are located topographically above anticipated flood zones, at elevations ranging from 120 to 155 ft above mean sea level (MSL).

Figure 2-1. 1986 Aerial Photograph of Kotzebue LRRS (reproduction).

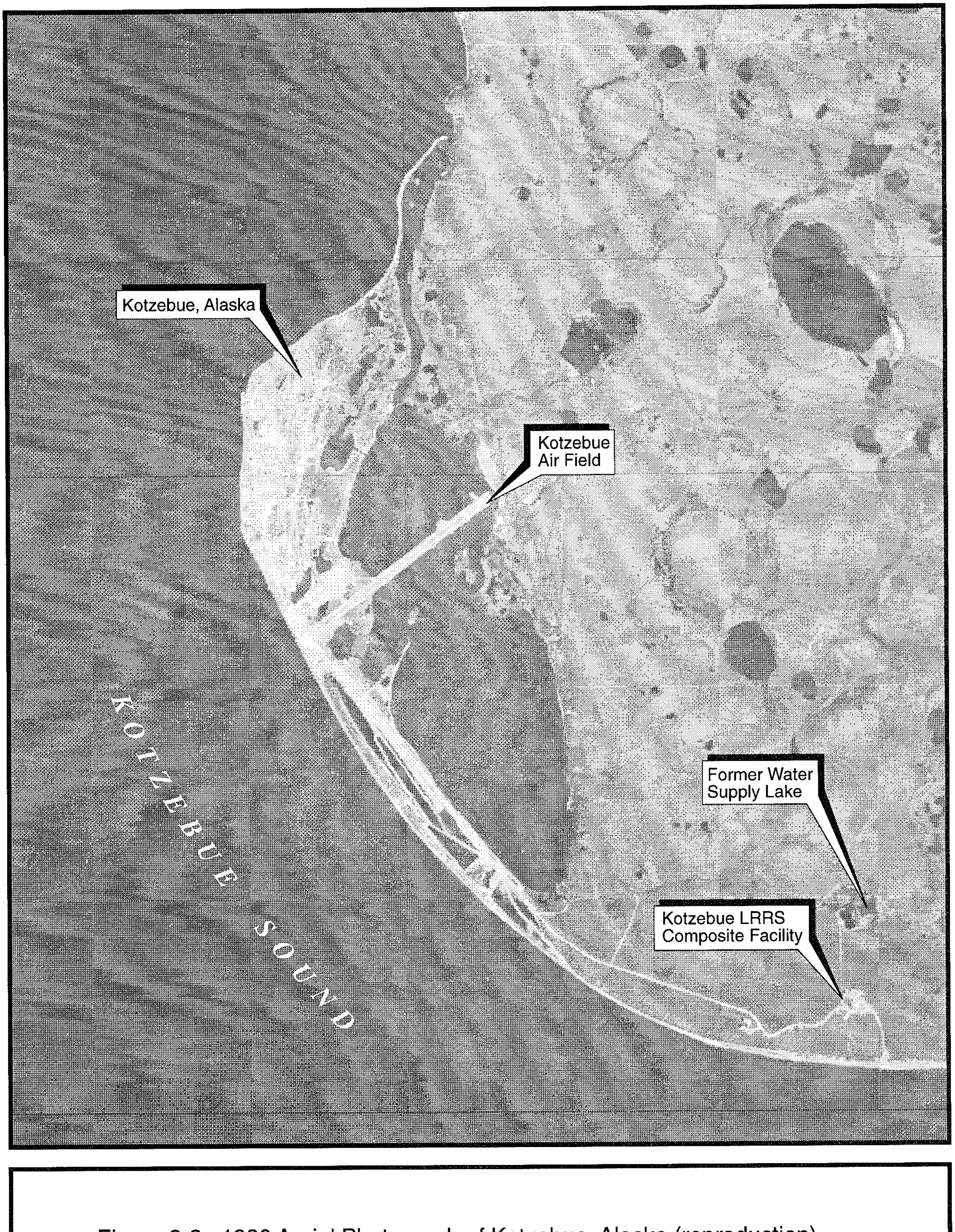

Figure 2-2. 1980 Aerial Photograph of Kotzebue, Alaska (reproduction).

2.2 CLIMATE

The climate of Kotzebue is strongly influenced by the seasonal coverage of sea ice in Kotzebue Sound, which in turn influences water movements and the occurrence and feeding patterns of the migrant and resident organisms that inhabit this region. A maritime climate predominates in summer when the sound is ice-free; a continental climate predominates in winter when the sound is covered with ice. Kotzebue Sound begins to freeze in mid-October and is covered with ice from November to May. Leads begin to develop in the pack ice as early as late May, and typically by late July Kotzebue Sound is free of pack ice. Coastal areas may be covered by shorefast ice for about 8 months of the year. Average annual temperatures range from maximum of 27^{o} F to a minimum of 14^{o} F. Table 2-1 summarizes climatological data for Kotzebue, Alaska. The historical record of precipitation indicates relatively low precipitation (mean annual precipitation of 8.5 inches), with over half of the precipitation occurring as rainfall during the summer months of July, August, and September. Mean annual snowfall is 43 inches, which occurs primarily during the months of October through April (Selkregg 1975). The total average annual precipitation is approximately 12 inches (USAF 1990a). The maximum 2-year, 24-hour precipitation is 1.8 inches (USAF 1985). No evapotranspiration data are reported for the area. The prevailing wind direction is out of the east-southeast, at an average speed of 11 knots.

2.3 GEOLOGY

The Baldwin Peninsula is composed of Quaternary glacial deposits with thicknesses exceeding 150 ft. Beaches are composed of sands and gravels, and the relatively straight shorelines are backed by wavecut terraces that form moderately steep sea cliffs in the unconsolidated glacial sediments (Hayes and Ruby 1979). The area around the Kotzebue LRRS is dominated by glacial moraine and drift deposits, which are overlain locally by a thin sandy beach deposit. The moraine and drift deposits are comprised of clays, silts, sands, and gravels; their total thickness is not known (USAF 1990a). A test well installed by the U.S. Geological Survey in 1950 indicated a silty clay (blue clay) marine deposit approximately 60 feet thick underlying approximately 19 feet of beach gravels at Kotzebue, Alaska (Cederstrom 1961).

TABLE 2-1. CLIMATOLOGICAL DATA FOR KOTZEBUE, ALASKA								
Month	Temperature		Rainfall Precipitation		Snowfall Precipitation		Wind	
	Mean Max (^{o}F)	Mean Min (^{o}F)	Mean (in)	Max (in)	Mean (in)	Max (in)	Mean Speed (kts)	Prevailing Direction
January	1	-13	0.4	0.8	5	5	13	East-Southeast
February	3	-11	0.3	0.7	6	7	12	East
March	7	-11	0.3	0.5	6	9	11	East
April	23	4	0.3	0.3	4	5	11	East
May	38	24	0.3	0.6	2	4	9	West
June	50	38	0.5	0.8	0	2	10	West
July	59	47	1.5	1.8	0	0	11	West-Northwest
August	56	45	1.5	2.2	0	0	12	West-Northwest
September	46	36	0.9	1.2	1	5	11	East-Southeast
October	30	20	0.5	0.6	6	6	11	East-Southeast
November	13	2	0.3	0.4	6	8	12	East
December	3	-10	0.3	0.4	7	8	11	East
Annual	27 (Avg)	14 (Avg)	7.1 (Total)	10.3 (Total)	43 (Total)	59 (Total)	11 (Avg)	East-Southeast
Source: Selkregg 1975.								

Permafrost has been identified at relatively shallow depths, ranging from less than 1 ft in native tundra, to a maximum of 7 ft below ground surface (BGS) at gravel pad sites, located on the tundra hill above the Kotzebue Sound beach area. Frozen ground was encountered at varying depths (i.e., minimum depth encountered was approximately 6 ft below ground surface) during the installation of monitoring wells at the Kotzebue LRRS beach area. Permafrost is moderately thick in the Kotzebue area and has been reported to a depth of 238 ft below grade. The permafrost is underlain by fine-grained sediments containing brackish subpermafrost water (Williams 1970).

2.4 GROUNDWATER

Groundwater occurs regionally beneath the moderately thick permafrost layer, termed subpermafrost water. Recharge and discharge of subpermafrost groundwater is limited to unfrozen zones that breach the overlying permafrost. Additionally, a very shallow system exists locally above permafrost, termed suprapermafrost water. The region where seasonal temperatures are sufficient to support melting of the near-surface and surface water system, is termed the active zone. Active zone water associated with the tundra hill sites at Kotzebue LRRS occurs intermittently (seasonally) and is seasonally present as thin, discontinuous, and isolated zones of suprapermafrost water. In this environment, active zone water is considered surface water by the Alaska Department of Environmental Conservation (ADEC).

Groundwater associated with the beach area at Kotzebue LRRS is restricted to a narrow zone adjacent to Kotzebue Sound, where the depth to permafrost is sufficiently depressed by marine influence to support a continuously saturated subsurface zone. The thickness of the near-beach aquifer system is estimated at approximately 7 to 9 ft, based on a competent silty clay confining layer identified at the ST05-Beach Tanks site.

Permafrost is impermeable to groundwater flow because pore spaces that would normally be available for the transport of groundwater are ice filled. Surface water bodies such as lakes, ponds, streams, and rivers, typically depress the upper surface of permafrost, changing the thickness and configuration of permafrost beneath the water body. Permafrost may be entirely absent beneath large water bodies. Because permafrost acts as an impermeable barrier to infiltration and aquifer recharge, surface water runoff is greatly increased in permafrost environments, enhancing the formation of lakes and wetlands.

2.4.1 Subpermafrost Water

The permafrost is underlain by fine-grained sediments containing brackish subpermafrost groundwater; increasing salinity with depth has been reported (Williams 1970). The salinity of subpermafrost groundwater in the Kotzebue area has prompted the development of surface water sources to satisfy local water supply requirements (USAF 1990a). The relatively thick permafrost layer beneath the Kotzebue LRRS acts as a confining layer between suprapermafrost surface water and subpermafrost groundwater regimes, inhibiting potential percolation and recharge of the subpermafrost groundwater system.

2.4.2 Suprapermafrost Water (Active Zone)

Active zone water occurs at Kotzebue LRRS in two distinct environments: the tundra hill and surrounding area and the Kotzebue Sound beach area. The tundra hill and surrounding area generally has near-surface silts that extend down to the shallow permafrost. Recharge of the active zone is limited by the low average annual precipitation and fine-grained nature of shallow soils. Flow is assumed to be relatively slow because of the low intrinsic permeability of the silty soils, and transport is likely limited by seasonal soil freezing in most areas. The occurrence of active zone water at sites associated with the tundra hill is highly variable and locally discontinuous.

The Kotzebue Sound beach area is comprised of coarse sands and gravels. Near-beach groundwater typically occurs between 3 and 4 ft BGS along the steepened beach face immediately adjacent to Kotzebue Sound, and from 6 to 7 ft BGS within the beach tank pads, based on data obtained from monitoring wells installed during the 1994 remedial investigation. The local groundwater flow direction is estimated to be to the southwest, toward Kotzebue Sound. Hydraulic gradients calculated at high tide on 24 July 1994 and low tide on 25 July 1994 fluctuated from 0.0032 ft per ft to 0.0049 ft per ft, respectively along the sample flowpath.

Characterization of the near-beach groundwater system at Kotzebue LRRS indicates that the groundwater is saline (brackish) in nature, is tidally influenced, and represents a non-potable resource. Tidal influences on the near-beach aquifer system can directly affect aquifer gradients and geochemistry, influencing contaminant migration and impacting an evaluation of remedial alternatives. Tidal monitoring and static water level measurements collected during the 1994 remedial investigation indicated that tidal fluctuation in Kotzebue Sound clearly impacts the near-beach aquifer in the vicinity of Kotzebue LRRS. However, based on the limited vertical extent of the water table aquifer and the observed tidal fluctuation,

it is unlikely that the tidal cycles have a significant effect on groundwater migration to the sound. Recharge of the near-beach aquifer system has not been addressed by previous studies. Recharge of the beach aquifer is likely controlled by the highly seasonal nature of active zone (suprapermafrost water) inputs that recharge the beach area from the tundra uplands. Kotzebue Sound tidal influence on the system, together with the seasonal nature of freshwater recharge, may result in some seasonal changes with respect to salinity and geochemistry; hydraulic gradients may also be slightly affected. Geochemical results indicated that mixing of seawater occurs in the fore-beach area at Kotzebue LRRS.

Natural attenuation processes (including biodegradation) are suggested to be active in the near-beach aquifer system at Kotzebue LRRS. However, the rate of contaminant degradation in groundwater is affected by low groundwater temperatures and lack of basic nutrients which limit the potential growth of indigenous microorganisms identified as capable of metabolizing petroleum hydrocarbons.

The seasonally intermittent nature of suprapermafrost water occurrence, and the salinity of subpermafrost groundwater in the Kotzebue area, has prompted the development of surface water sources to satisfy local water supply requirements. However, some domestic consumers in Kotzebue may employ shallow wells screened in spit gravels to obtain suprapermafrost water from a zone ranging between 4 and 20 ft in thickness, although it is very unlikely that this would provide a dependable supply of water because the active zone is frozen for approximately 8 months of each year (USAF 1990a). The domestic wells closest to the installation are all located in the City of Kotzebue, 4 miles away. There are no known uses of surface water or groundwater located within a 3-mile radius of Kotzebue LRRS.

2.5 SURFACE WATER

The surface waters of Alaska are classified in accordance with both their present and their potential utilization and are distinguished between fresh and marine waters (ADEC 1995). All of the freshwater streams in the Kotzebue LRRS area are classified Freshwater IA Water Supply (drinking, culinary, and food processing). Kotzebue Sound is classified as a Marine IIA Water Supply (aquaculture, seafood processing, and industrial) (ADEC 1995).

2.5.1 Surface Water Occurrence

Surface waters associated with Kotzebue LRRS and the surrounding area include Kotzebue Sound, small lakes and ponds, wetlands, bogs, and small streams. Lake and pond waters are characteristically a brown color due to naturally occurring tannins in the water draining the adjacent tundra (USAF 1990a). Surface water bodies within a one-mile radius of the installation include the following:

- **June Creek**--June Creek is located approximately one mile north of the Composite Facility and flows to the northwest into the large lagoon (brackish) adjacent to Kotzebue Sound. Two small unnamed tributaries of June Creek have been mapped approximately 0.25 miles north and 0.25 miles east-northeast (former LRRS water supply lake outlet) of the Composite Facility (USGS Topographic Map, Kotzebue D2 Quadrangle 1951, Revised 1988). It is suspected that these small tributaries are only active during a relative short period of time in the spring during snow melt (break-up). Aerial photographs taken over several years indicate that these small tributaries do not provide active flow during the late spring and summer months.

- **LRRS Former Water Supply Lake**--The former Kotzebue LRRS water supply lake is located approximately 0.25 miles east-northeast of the Composite Facility, at an approximate elevation of 37 ft above MSL. The lake is approximately 1,000 ft in length and 600 ft wide. However, during the mid and late summer months, the lake's volume is significantly reduced. The total depth of the lake has not been determined, but aerial photographs indicate that the lake is relatively shallow.

- **Wetlands**--Wetlands are located approximately 0.25 miles east of the Composite Facility adjacent to and surrounding the former water supply lake.

- **Kotzebue Sound**--Kotzebue Sound is located approximately 0.25 miles west of the Composite Facility.

- **Miscellaneous Ponds**--Intermittent ponding has been reported southwest of the Composite Facility along the moderately sloping hillside above Kotzebue Sound. The ponded water observed at the installation is a result of rainfall and snow melt, and is most pronounced in late spring/early summer.

2.5.2 Surface Water Drainage

Kotzebue LRRS is situated on top of a tundra hill located approximately 0.25 miles east of Kotzebue Sound. Most of the sites at Kotzebue LRRS range in elevation from 120 ft to 155 ft above MSL. Surface water runoff originating from Kotzebue LRRS is topographically directed either west toward Kotzebue Sound, or east toward the adjacent wetlands. Runoff draining east could potentially reach the former water supply lake.

Melting of the annual snowpack usually occurs over a relatively short time period each year, referred to as break-up, and coincides with the greatest annual surface flow at Kotzebue LRRS. The average break-up and freeze-up dates for the Kotzebue area are 17 May to 8 June and 2 October to 5 November, respectively (Schroeder et al. 1987). Soils remain frozen during much of break-up, and the potential for contaminant migration via the surface water pathway is suspected to be low (USAF 1990a). Surface water infiltration rates have not been published for Kotzebue, but recharge to the tundra hill active zone is limited by the low average annual precipitation, extended periods of sub-freezing conditions, and low permeability of native soils.

2.5.3 Surface Water Drinking Supply

Historically, the installation used a small lake as a water supply (see Figure 1-2). However, use of the water supply lake was discontinued in 1985 when the installation became a minimally attended radar system. Drinking water at Kotzebue LRRS is currently obtained from the City of Kotzebue. The City of Kotzebue uses Devil's and Vortac Lakes, located near the town, as municipal water supply sources (USAF 1990a).

2.6 OCEANOGRAPHY OF KOTZEBUE SOUND

Kotzebue Sound is a shallow, relatively flat embayment of the southeastern Chukchi Sea, with water depths averaging 46-52 ft and reaching depths of 82 ft (Naidu and Gardner 1988). The tides of Kotzebue Sound are relatively small and are of the mixed, semi-diurnal type. The mean tide range is 2.1 ft and the diurnal tide range is 2.7 ft (U.S. Department of Commerce 1992). Wind-driven currents exert a greater influence on sea level variation than those caused by tides. Strong and persistent westerly winds can cause storm surges and coastal flooding, although the frequency of these events are tempered by the presence of sea ice which reduces the fetch of open water exposed to wind.

The bottom sediments of the sound consist of poorly to very poorly sorted silts with some clay and sand, which indicates a low-energy depositional environment (Naidu and Gardner 1988). The relatively high organic carbon content (as high as 1.9 mg/kg dry weight) of the bottom sediments of Kotzebue Sound are associated with fine, poorly sorted sediments. The sediment organic matter may be terrestrial, originating from the discharge of rivers and smaller coastal streams (Naidu and Gardner 1988). The Noatak River, which enters Kotzebue Sound at the outlet of Hotham Inlet (Kobuk Lake) approximately 10 miles north of Kotzebue, contributes significant quantities of suspended sediment to Kotzebue Sound. The sediment plume from the Noatak may flow in either of three general directions: 1) east into Hotham Inlet (Kobuk Lake), 2) westward along the northern shoreline of the sound and then northwest to Point Thompson, and 3) southward along the shoreline in front of the City of Kotzebue and into the central basin of Kotzebue Sound. A portion of the Noatak sediment plume has been observed along the west shore of the Baldwin Peninsula as far south as Cape Blossom (Scott 1977).

The predominant water flow in Kotzebue Sound is directed into the southeastern Chukchi Sea (Johnson 1988). The circulation and physical properties within Kotzebue Sound are influenced by ice formation and melting during fall and spring, and freshwater river inputs from rivers and streams during summer. Melting sea ice and the input of freshwater reduce surface water salinity and lead to stratification of the water column in spring and summer. Depending on river flow, wind, and tides, freshwater input from the Noatak River, and from the Kobuk and Selawik rivers via Hotham Inlet (Kobuk Lake), can lead to the occurrence of low salinity water along the shore of the City of Kotzebue (Georgette and Loon 1993). Ice formation during fall and winter leads to increasing bottom salinity and cooler bottom water temperatures, which results in outflow of bottom waters from Kotzebue Sound (Kinder et al. 1977). During summer the sound becomes stratified. In the outer portion of the sound there appears to be a three-layered system, where near-surface and near-bottom waters flow out of the sound; water at intermediate depths enters the sound. The occurrence during summer of a weak inflowing current around Cape Espenberg and a weak outflowing current around Cape Krusenstern has also been reported (Scott 1977). The inner portion of Kotzebue Sound is stratified into two layers during summer, with a sharp pycnocline due to changes in both temperature and salinity with depth (Kinder et al. 1977). Currents within the sound have been described as weak and variable, and predominantly tidal (Flemming and Heggarty 1966).

2.7 BIOLOGICAL HABITATS

The Baldwin Peninsula is a long narrow rolling upland composed of Quaternary gravel till and loess deposits, covered with a thin layer of water-laid silt and peat lenses (McCulloch et al. 1965; McCulloch et al. 1966). The entire peninsula is covered with tundra vegetation. Because of the location and morphology of the Baldwin Peninsula, there are a number of characteristics of the peninsula that distinguish it from the nearby areas of the mainland. These characteristics include the following:

- Although the northern limit of tree growth is approximately 75 miles north of Kotzebue, the environment of the Baldwin Peninsula is treeless (Georgette and Loon 1993). However, small dwarf shrubs, primarily willows and alder, can be found.

- Because of the limited land access via the narrow peninsula, few caribou or moose occur on the peninsula. The predators of these large land animals (e.g., wolves, brown bear, and grizzly bear) are also infrequent visitors to the peninsula.

- Because the peninsula lies within the relatively protected waters of Kotzebue Sound, marine mammals that follow the pack ice (e.g., walrus, bearded seal, polar bear) typically occur within the sound only for a short period in spring when leads open in the sea ice.

- No large rivers are found on the peninsula. The Noatak River, located approximately 10 miles north of Kotzebue, is the nearest river where anadromous fish spawn.

- Large nesting colonies of seabirds are absent, except at the southern end of the peninsula near the mouth of Eschscholtz Bay, approximately 45 miles to the south of Kotzebue (Divoky and Springer 1988).

Important features of the region north of the Arctic Circle are the seasonal activity of resident and migrant species and the occurrence of permafrost. In general, the long cold winters preclude activity by all but the hardiest of resident species. Notable among these are the Arctic hare and the snowy owl. However, beginning in May or early June there is a burst of activity, particularly due to the influx of

migratory birds and marine mammals, spawning of fish (particularly herring and salmon), and the growth of tundra vegetation that attracts humans as well as wildlife.

Tundra vegetation and shallow ponds and wetlands form the basis of the terrestrial ecosystem in the vicinity of the radar station. Because of the limited drainage due to shallow permafrost, much of the terrestrial environment may be considered wetland. A number of small ponds and lakes occur within the boundaries of the Kotzebue LRRS. These habitats support a variety of plant species, which in turn support small mammals and their predators. The detritus produced by aquatic plants also supports benthic insect larvae and plankton, which in turn supports migrant species of water birds, including phalaropes and loons.

2.8 DEMOGRAPHICS

Kotzebue LRRS is operated as a minimally attended radar installation. A single radar technician is housed in the City of Kotzebue. Additional personnel provide maintenance on an as-needed basis.

Kotzebue has an estimated population of 3,649 people based on the 1991 federal census results. The community of Kotzebue serves as a regional service and distribution center for the Northwest Arctic Borough, an area of 37,300 square miles incorporating 11 villages: Kotzebue, Ambler, Buckland, Deering, Kiana, Kivalina, Kobuk, Noatak, Noorvik, Selawik, and Shungnak. Fifty five percent of the population distribution within the Northwest Arctic Borough resides in the 10 smaller villages, with the remaining 45 percent residing in Kotzebue. Kotzebue is a predominantly Inupiat community, with Alaska Natives comprising 75 percent of its population (Fall and Utermohle 1993). Historically, Kotzebue has grown as a transportation hub for river travel along the Noatak, Kobuk, and Selawik Rivers, as well as for air travel to northern Alaska. Kotzebue's position as a modern regional center emerged after World War II, largely owing to the establishment of government facilities and services there. Much of Kotzebue's population growth has resulted from influx from surrounding villages (Fall and Utermohle 1993).

The Kotzebue economy is sustained by the regional offices and facilities of the many state and federal agencies that serve northwest Alaska and are located in Kotzebue (USAF 1990a). The top source of income is from jobs relating to federal, state and local governments, including jobs associated with

schools. Employment by industry indicates that most jobs were in services (25 percent), commercial fishing (14 percent), education (13 percent), and retail trade (11 percent) (Fall and Utermohle 1993).

It is estimated that greater than 70 percent of Kotzebue's population engages in subsistence activities, including an estimated 69 percent processing wild resources (e.g., cleaning and preparation of wild game, drying fish, canning), 36 percent hunting, 53 percent fishing, 3 percent trapping, and 61 percent gathering wild plants (Fall and Utermohle 1993). The total subsistence harvest by resource is comprised of land mammals (especially caribou and moose) at 31 percent, fish other than salmon (e.g., sheefish) at 27 percent, marine mammals (e.g., bearded seals) at 26.8 percent, and salmon (primarily chum salmon) at 13 percent (Fall and Utermohle 1993).

2.9 LAND USE

Currently, Kotzebue LRRS is used solely as a minimally attended radar facility, with no active housing facilities or military presence. PMC-Frontec is responsible for maintenance of real property facilities, which includes the radar facility, abandoned buildings, roads, grounds, and antenna structures. The active portion of the installation, including the radar facility and nearby structures, is completely fenced and secure. Abandoned housing facilities and other structures surrounding the radar facility are closed to the public, but are located outside the fenced area (USAF 1993).

The property occupied by Kotzebue LRRS is not used by other private or governmental agencies, with the exception of the Navigational Aid Building 101 currently used to house experimental equipment belonging to the Geophysical Institute at the University of Alaska. The area provides suitable habitat for a wide variety of wildlife, and subsistence and recreational use may occur within or near installation boundaries. Subsistence use may include berry picking in adjacent tundra wetlands, terrestrial hunting along the tundra hill and surrounding area, and marine hunting and fishing along the Kotzebue Sound beach area. Recreational uses may include all terrain vehicle (ATV) use along roads and beach areas, summer picnicking and wading along beach areas, beach combing, and recreational hunting and fishing. Additionally, the beach area near Kotzebue LRRS has been reportedly used as a staging area for commercial fishing of chum salmon and as a rifle range by local residents (USAF 1993).

Kotzebue LRRS is anticipated to maintain radar facility operations at current (or possibly reduced) levels over the next few years. Remedial actions at IRP sites and demolition of abandoned structures are future activities anticipated at the installation. Future demands on fisheries and wildlife are primarily linked to native subsistence use, with resource management in the area under the jurisdiction of the Alaska Department of Fish and Game. Future outdoor recreation activities at Kotzebue LRRS and surrounding area are anticipated to be consistent with current recreational uses associated with the area (USAF 1993). Future land use issues and strategies associated with Kotzebue, Alaska and surrounding areas have been considered by the Northwest Arctic Borough (NAB) and are presented in the NAB Comprehensive Plan (NAB 1992).

3.0 PREVIOUS IRP INVESTIGATION ACTIVITIES

Several previous investigations have been conducted at Kotzebue LRRS, including a Phase I records search, Stage 1 and Stage 2 RI/FS programs, beach tank removals, an environmental baseline survey of Navigational Aid Building 101, and site surveys in 1993 and 1994.

3.1 PHASE I RECORDS SEARCH

In 1985, a Phase I Records Search was conducted for the AAC Northern Region, which includes Kotzebue LRRS. The purpose of the Phase I records search was to identify and prioritize past disposal sites that may pose a hazard to public health or the environment as a result of contaminant migration to surface water or groundwater, and to identify contaminants that could have an adverse effect due to their persistence in the environment. Twelve sites were identified from a review of base records, interviews with current and former employees, information gathered during field surveys, and from interviews with local, state, and federal agency representatives. Based on an additional assessment of factors such as site characteristics, waste characteristics, and the potential for contaminant migration, eight sites were identified for further IRP evaluation (USAF 1985).

3.2 STAGE 1 RI/FS

In 1988, a Stage 1 RI/FS was conducted at Kotzebue LRRS to assess past disposal and spills of hazardous materials, and to develop remedial actions for sites thought to pose a threat to human health or the environment. Twelve sites were identified for investigation (Table 3-1). These sites included the eight sites identified for further IRP evaluation during the Phase I Records Search. Based on a 1987 field reconnaissance effort, two of the twelve sites proposed for investigation were dropped because the reconnaissance did not provide evidence of contamination or environmental stress (USAF 1990a). A

TABLE 3-1. SITE IDENTIFICATION FOR 1988 STAGE 1 RI/FS

USAF Site Designation	Site Name	Site Descriptions
SS01	Waste Accumulation Area No. 1	This site is located south of Building No. 205, west of the installation access road. The site is an approximate 80x160 ft gravel pad formerly used to store drummed waste oils and/or solvents.
SS02	Waste Accumulation Area No. 2 /Landfill	The landfill is located on a triangular piece of land adjacent to and north of the former fuel storage tanks on the beach. Waste accumulation Area No. 2 is located northeast of the former fuel storage tanks adjacent (south) to the landfill. The landfill was used until approximately 1974. Waste accumulation Area No. 2 was used until approximately 1972; in 1975, the site was cleaned up and the area graded.
SD03	Road Oiling	Waste oils, spent solvents, ethylene glycol, and other shop wastes were reportedly used for dust control on the installation road system. The use of waste oil for dust control was practiced until 1984.
ST05	Beach Tanks	The site is located approximately 0.25 miles southwest of the Composite Facility. The site is associated with the former POL (diesel fuel) storage tanks located adjacent to Kotzebue Sound and comprises an area of approximately 250x900 ft.
SS06	Spill No. 1	The site is located near the officers wing of Building 103 (northern most wing). A diesel fuel leak reportedly occurred in a fuel line in the mid-1970's due to a coupling failure.
SS07	Lake	The lake is located approximately 0.25 miles northeast of the Composite Facility. The lake served as the installation drinking water supply until 1985.
SS08	Barracks Pad	The site is located adjacent to the Composite Facility, between two building wings. The site is an approximate 25 x 40 ft gravel pad reportedly used to store chemicals such as solvents, rust inhibitors, chlorobromomethane, and various fluorocarbons. Small above ground diesel fuel tanks located adjacent to the barracks pad are reportedly a potential source of diesel fuel contamination.
SS09	PCB Spill	The site is located at the White Alice Station, approximately 0.5 miles northwest of the Composite Facility. A PCB spill reportedly occurred on a portion of a 10 x 10 ft gravel pad.
SS10	Solvent Spill	The site is located at the White Alice Station, approximately 0.5 miles northwest of the Composite Facility. A solvent spill had reportedly occurred covering an approximate 10 x 20 ft area on the edge of a gravel pad.
SS11	Fuel Spill	The site is located at the White Alice Station, approximately 0.5 miles northwest of the Composite Facility. A jet fuel spill reportedly occurred which covered an approximate 50 x 60 ft area.
SS12	Spill No. 2	The site is located west-southwest of the Composite Facility power plant. A diesel fuel spill reportedly occurred in 1979-1980 when the day tank behind the power plant was overfilled.
SS12	Spill No. 3	The site consists of an approximate 1.5 acre area adjacent to, and west-southwest of, the Composite Facility. A large diesel fuel leak reportedly occurred via a hole in a distribution line identified in 1984. The fuel line was repaired, and approximately 4,000 gal of diesel fuel was reportedly collected in recovery trenches subsequently installed by the Air Force.

USAF Stage 1 RI/FS (USAF 1990a)

Stage 1 RI was conducted at the remaining 10 sites. This investigation included soil/sediment sampling at all sites, surface water sampling at Site SS07-Lake, a soil gas survey at the SS12-Spills No. 2 and 3 sites, water-flooding pilot testing at the SS12-Spill No. 3 site, and aeration of soils at the SS11-Fuel Spill site (USAF 1990a). Identified contaminants included petroleum hydrocarbons, polychlorinated biphenyls (PCBs), delta-BHC, 4,4'-DDT, 4,4'-DDE, and 4,4'-DDD. Analyses conducted on soil and surface water samples collected during the Stage 1 RI are summarized in Table 3-2. Maximum concentrations of organic compounds and metals identified in soil and surface water are provided in Table 3-3. A qualitative ecological and human health risk screening approach was developed to identify sites warranting further consideration for possible remedial actions. This screening approach did not identify any sites that posed substantial ecological or human health risks (USAF 1990a). Despite these findings, several sites were recommended for further remedial action based on soil analyses indicating contamination above recommended cleanup levels. The sites recommended for further activity were SS12-Spill No. 2, SS12-Spill No. 3, SS01-Waste Accumulation Area No. 1, SS09-PCB Spill, SS10-Solvent Spill, SS11-Fuel Spill, and ST05-Beach Tanks sites.

3.3 STAGE 2 RI/FS

In 1989-1990, a Stage 2 RI/FS was conducted at Kotzebue LRRS to evaluate the sites recommended for further remedial action. Field activities included an investigation of soil and groundwater at the STO5-Beach Tanks site; pilot-scale remediation tests involving excavation and landfarming; *in situ* enhanced bioremediation; excavation and off-site disposal of PCB contaminated soils; and removal of four transformers (USAF 1990b). Soil and groundwater at the STO5-Beach Tanks site were characterized to quantify the nature and magnitude of contamination at this site, delineate the horizontal and vertical extent of contamination, determine the hydrogeologic setting, and complete a feasibility study of remedial alternatives. Analyses conducted on soil and groundwater samples collected during the Stage 2 RI/FS are presented in Table 3-4. Table 3-5 presents petroleum hydrocarbon concentrations measured in samples obtained during the landfarm and *in situ* enhanced bioremediation programs.

Chemical substances identified in soil and groundwater samples from the ST05-Beach Tanks site included 2-methylnaphthalene, toluene, total xylenes, ethylbenzene, and petroleum hydrocarbons. Table 3-6 presents maximum detected concentrations of petroleum hydrocarbons in soil and groundwater at

TABLE 3-2. ANALYSES PERFORMED ON SOIL AND SURFACE WATER SAMPLES DURING 1988 STAGE 1 RI/FS AT KOTZEBUE LRRS

Analyte	Analytical Method	Site Identification
Soils/Sediment		
Total Petroleum Hydrocarbons	SW3550/E418.1	All 10 sites
Metals Screen (23 metals, exclude boron & silica)	SW3050/SW6010	SD03-Road Oiling, SS01-Waste Accumulation Area No. 1
Organochlorine Pesticides and PCBs	SW3550/SW8080	All sites except ST05-Beach Tanks
Volatile Organic Compounds	SW8240	All sites except SS09-PCB Spill
Soil Moisture Content	ASTM D-2216	All 10 sites
Surface Water		
Total Petroleum Hydrocarbons	E418.1	SS07-Lake
Metals Screen (23 metals) by ICP	SW3005/SW6010	SS07-Lake
Purgeable Halocarbons	SW5030/SW8010	SS07-Lake
Purgeable Aromatics	SW5030/SW8020	SS07-Lake
Organochlorine Pesticides and PCBs	SW3510/SW8080	SS07-Lake
Semivolatile Compounds	SW3510/SW8270	SS07-Lake

USAF Stage 1 RI/FS (USAF 1990a).

TABLE 3-3. SUMMARY OF MAXIMUM ORGANIC AND INORGANIC COMPOUND CONCENTRATIONS DETECTED IN SOIL AND SURFACE WATER DURING 1988 STAGE 1 RI/FS AT KOTZEBUE LRRS

USAF Site Designations	Media	TPH[a] (mg/kg)	Pesticides (mg/kg)				Organic Compounds and Peak Concentrations (mg/kg)				
			4,4'-DDD	4,4'-DDE	4,4'-DDT	Delta-BHC	PCBs Aroclor 1260	Benzene (mg/kg)	Ethylbenzene (mg/kg)	Toluene (mg/kg)	Total Xylenes (mg/kg)
*Maximum Organic Compound Concentrations in Soil[c]											
SS12-Spill No. 2	Soil	10,700	0.027	ND[b]	0.14	ND	ND	ND	1.2	1.0	47
SS12-Spill No. 3	Soil	99,200	2.3	ND	5.7	0.11	ND	0.86	22	28.0	170
SDO3-Road Oil	Soil	97	0.37	ND	ND	ND	ND	ND	ND	ND	ND
SS01-Waste Acc. Area No. 1	Soil	16,200	0.98	ND	ND	ND	ND	ND	ND	ND	ND
SS11-Fuel Spill	Soil	23,100	ND	ND	0.098	ND	ND	ND	ND	5.9	200
SS10-Solvent Spill	Soil	1,460	ND	ND	0.22	ND	25.0	ND	ND	ND	ND
SS09-PCB Spill	Soil	4,600	ND	ND	0.062	ND	32.0	ND	ND	ND	ND
SS08-Barracks	Soil	5,960	0.19	ND	ND	ND	ND	ND	ND	ND	ND
SS07-Lake	Sediment	ND	1.10	0.19	2.6	ND	3.4	ND	ND	ND	ND
	Surface Water	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ST05-Beach Tanks	Soil	5,300	NA[d]	NA	NA	NA	NA	ND	ND	6.2	ND

*Maximum Inorganic Compound Concentrations in Soil and Water

	Media	Inorganic Compounds														
		Aluminum	Barium	Beryllium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Nickel	Sodium	Vanadium	Zinc
SD03 (Road Oil) (mg/kg)	Soil	8,800	170	0.4	3,300	15	8	15	14,200	8	3,400	230	18	50	20	36
SS01 (Waste No. 1) (mg/kg)	Soil	3,800	95	0.1	27,900	13	6	11	13,300	8	12,000	590	29	90	14	120
SS07 (Lake) (mg/L)	Surface Water	ND	0.05	ND	17	ND	ND	ND	10	ND	5.2	0.02	ND	3.3	ND	0.01

[a] TPH = Total petroleum hydrocarbons.
[b] ND = Concentration below detection limit.
[c] Soil contaminant values are reported as "dry weight" results.
[d] NA = Not analyzed.
*Data Quality Assurance/Quality Control (QA/QC) validation discussed in Section 4.2, 1988 Stage 1 RI/FS Final Report. (USAF 1990a)

TABLE 3-4. ANALYSES PERFORMED ON SOIL AND GROUNDWATER SAMPLES DURING 1989-1990 STAGE 2 RI/FS AT KOTZEBUE LRRS

Analyte	Analytical Method	Site Identification
	Soils	
Total Petroleum Hydrocarbons	SW3550/E418.1	ST05-Beach Tanks, Landfarm, SS12-Spill No. 3, SS11-Fuel Spill
Polychlorinated Biphenyls	SW3550/SW8080	SS-11 Fuel Spill, SS09-PCB Spill
Semivolatile Organics	SW3550/SW8270	ST05-Beach Tanks
Microbial Enumeration (total, viable, and phenanthrene-specific)	Hobbie et al. 1977	ST05-Beach Tanks, Landfarm
Soil Moisture Content	ASTM D2216	All sites
Permeability	USCOE Manual EM 110-2-1906 App. VII and X (30 Nov. 1970)	ST05-Beach Tanks
Soil Gradation	ASTM D 422-63 (1972)	ST05-Beach Tanks
	Groundwater	
Total Petroleum Hydrocarbons	E418.1	ST05-Beach Tanks
Purgeable Aromatics	SW5030/SW8020	ST05-Beach Tanks
Semivolatile Organic Compounds	SW3510/SW8270	ST05-Beach Tanks
Biochemical Oxygen Demand	E 405.1	ST05-Beach Tanks
Chemical Oxygen Demand	E 410.4	ST05-Beach Tanks
Total Dissolved Solids	E 160.1	ST05-Beach Tanks
Microbial Enumeration (total, viable, and phenanthrene-specific)	Hobbie et al. 1977	ST05-Beach Tanks

USAF 1989-1990 Stage 2 RI/FS (USAF 1990b).

TABLE 3-5. TOTAL PETROLEUM HYDROCARBON CONCENTRATIONS IN SOIL SAMPLES COLLECTED FROM THE LANDFARM, NATIVE TUNDRA, AND DISTURBED TUNDRA, DURING STAGE 2 RI/FS AT KOTZEBUE LRRS.

Sampling Date	Number of Samples	Mean Concentration (mg/kg)	Standard Deviation	Standard Error
LANDFARM SITE				
August 8, 1989	9	9,656	3,946	1,315
September 12, 1989	9	5,237	1,385	462
September 26, 1989	9	5,919	2,602	867
July 25, 1990	10	4,044	567	179
September 24, 1990	10	2,359	551	174
NATIVE TUNDRA (SS12-Spill No. 3 Site)				
August 8, 1989	5 4[a]	6,018 7,500	5,513 5,088	2,465 2,544
September 12, 1989	5	5,338	7,363	3,293
September 26, 1989	5	5,338	7,363	625
July 24, 1990	10	3,118	2,199	695
September 24, 1990	10 9[b]	2,044 1,306	2,604 1,230	824 410
DISTURBED TUNDRA (SS11-Fuel Spill Site)				
August 8, 1989	5	6,310	1,709	764
September 12, 1989	5	1,597	1,533	686
September 26, 1989	5	726	608	272
July 25, 1990	10	1,013	469	148
September 24, 1990	10	575	603	191

[a] If one analysis of 90 mg/kg is removed as an apparent outlier.

[b] If one analysis of 8,680 mg/kg is removed as an apparent outlier.

USAF 1989-1990 Stage 2 RI/FS (USAF 1990b).

TABLE 3-6. MAXIMUM DETECTED CONCENTRATIONS IN ST05-BEACH TANKS SOIL AND GROUNDWATER SAMPLES DURING 1989-1990 STAGE 2 RI/FS AT KOTZEBUE LRRS

Analytes	Soils (mg/kg)	Groundwater (mg/L)
Petroleum hydrocarbons	21,000	8,700
Ethylbenzene	NA[a]	0.0063
Toluene	NA	0.034
Xylenes	NA	0.140
2-Methylnaphthalene	26	NA
Dissolved oxygen	NA	16
Chemical oxygen demand	NA	526
Biological oxygen demand	NA	81
Total dissolved solids	NA	1,250
Microbial Enumeration[b]		
Total bacteria	NA	5.73
Colony forming	NA	1.30
Fluorescent pseudomonad	NA	8.0
Phenaphthrene degraders	NA	1.03

[a] NA = Not analyzed.

[b] Total bacteria (x 10^7 per mL)
Colony forming units (x 10^7 per mL)
Fluoresent pseudomonads (x 10^1 per mL)
Phenaphthrene degraders (x 10^6 per mL).

USAF 1989-1990 Stage 2 RI/FS (USAF 1990b).

Site ST05. The qualitative risk screening method developed during the Stage 1 RI/FS was used to assess potential health and environmental risks at the site. The Stage 2 RI/FS concluded that petroleum hydrocarbons at the STO5-Beach Tanks site posed a potentially significant risk to aquatic organisms (USAF 1990b). Subsequently, several operable units were identified in order to evaluate possible remedial actions. Table 3-7 provides a description of the operable units, potential remedial alternatives, and the remedial action recommended.

3.4 BEACH TANK REMOVALS

Three diesel fuel storage tanks were located approximately 0.25 miles southwest of the Composite Facility, adjacent to Kotzebue Sound. Two of the tanks were 50 ft in diameter and 22 ft high, each with a storage capacity of 7,890 barrels. The third tank measured 44 ft in diameter and 24 ft high, with a storage capacity of 6,500 barrels (USAF 1990b). Approximately 39,500 gallons of diesel fuel was estimated to remain in the three storage tanks. In 1992, the USAF removed the fuel and the three storage tanks from the site. Remaining accessory structures included the bermed containment areas, asphalt tank pads within the bermed areas, and a fuel pump house.

3.5 ENVIRONMENTAL BASELINE SURVEY (NAVIGATIONAL AID BUILDING 101)

In July 1993, an environmental baseline survey was conducted at Navigational Aid Building 101 (see Figure 1-3). The environmental baseline survey was conducted for the University of Alaska, Fairbanks Facility Planning and Project Services Department as a requirement for USAF's long-term lease of this facility. The environmental baseline survey included the collection of eight building material samples for asbestos and four hand-augered soil samples for diesel range organics (DRO) analysis.

This survey identified asbestos in siding panels on the exterior walls and floor of Navigation Aid Building 101, and in the interior wall wainscoting (Shannon and Wilson, Inc. 1993). Concentrations of DROs measured in this survey ranged from 70 to 4,200 mg/kg.

TABLE 3-7. OPERABLE UNIT DESCRIPTION AND REMEDIAL ALTERNATIVE SELECTION SUMMARY FOR USAF STAGE 1 AND STAGE 2 RI/FS INVESTIGATIONS AT KOTZEBUE LRRS

Operable Unit	Operable Unit Description	Remedial Alternatives Selected for Detailed Analysis	Selected Remedial Alternative
Operable Unit A - Soils/Fill Material (Stage 1 RI/FS)			
SS12 - Spill No. 2 and 3 SS01 - Waste Accumulation Area No. 1	Sites in this operable unit have been selected based on the nature of the existing soils. Kotzebue LRRS consists of various buildings, roads, and pads to facilitate overlain site operations. In these areas, the native tundra has been replaced with fill material, and excavation activities to remove contamination could proceed without further damage to the native tundra.	- Non Action/Institutional Controls - Capping - Excavation/On-Site Thermal Treatment - Excavation/On-Site Landfarming - Excavation/Transportation/Reclamation	- Excavation/On-Site Landfarming
Operable Unit A - Beach Sands and Gravels/Fill (Stage 2 RI/FS)			
STO5 - Beach Tanks	This operable unit includes the beach sands and gravels west of the access road at the ST05 site, as well as fill material that was imported to the site to construct the tank pads (generally beach sands and gravels). Alternatives developed for this operable unit are designed to minimize disruptions to the beach.	- Non Action/Institutional Controls - Excavation/Landfarming - Soil Vapor Extraction - In-Situ Bioremediation (no groundwater recapture)	- In-Situ Bioremediation (no groundwater recapture)
Operable Unit B - Soils/Native Tundra			
SS12 - Spill No.3 SS11 - Fuel Spill	Sites in this operable unit have an intact tundra ground cover, although part of the site may consist of fill material. Alternatives developed for this operable unit are designed to minimize further disruptions to the tundra.	- Non Action/Institutional Controls - In-Situ Enhanced Biodegradation	- In-Situ Enhanced Biodegradation
Operable Unit C - Soils with PCBs			
SS09 - PCB Spill SS10 - Solvent Spill	Soils containing PCB contamination were identified as a separate operable unit in order to address technologies specific to PCB remediation.	- Non Action/Institutional Controls - Excavation/Off-Site Disposal - In-Situ Enhanced Biogradation	- Excavation/Off-Site Disposal
Operable Unit D - Groundwater			
STO5 - Beach Tanks	This operable unit is the groundwater beneath the beach sands and gravels at the STO5 site.	- Non Action/Institutional Controls - In-Situ Closed Loop Bioremediation - In-Situ Bioremediation (no ground-water recapture)	- In-Situ Bioremediation (no groundwater recapture)

Stage 1 and 2 RI/FS (USAF 1990a,b).

This survey concluded that spillage or overflow from the fuel delivery system to the generator and diesel furnace in Navigational Aid Building 101 most likely resulted in soil contamination in the immediate vicinity of the tanks, and along the fuel pipeline corridor connecting the above-ground fuel tanks with the building (Shannon and Wilson, Inc. 1993).

3.6 1993/1994 SITE SURVEYS

On 29 September 1993, a site survey was conducted at Kotzebue LRRS and the surrounding area. The site survey was conducted to evaluate current site conditions, identify potential areas of concern, and obtain information necessary to prepare RI/FS scoping documents for future field activities. Based on the 1993 site survey and subsequent discussions, ten additional areas of concern (AOC) were identified for consideration (Table 3-8).

In June 1994, another site reconnaissance was conducted at Kotzebue LRRS. This reconnaissance identified two additional areas of concern for investigation:

- AOC11-Truck Fill Stand: A truck fueling pad was identified north of the active radar dome, adjacent to the facility access road. The site consists of a gravel pad (approximately 10 ft x 8 ft in area) with fuel delivery system pipes emerging from a concrete form situated atop the gravel pad. Visual and olfactory evidence of petroleum hydrocarbon contamination was noted within the gravel fill material during inspection. Runoff from the site drains to the southwest. Soil staining was observed along the drainage pathway.

- AOC12-Radar Dome Soil Staining: This site is a relatively small (10 ft x 10 ft) but distinct area of stained soils located approximately 30 ft west of the active radar dome. Visual and olfactory evidence of petroleum hydrocarbon contamination was limited to gravel fill materials.

TABLE 3-8. AREAS OF CONCERN IDENTIFIED DURING THE 1993 SITE SURVEY, KOTZEBUE LRRS

Site Designation	Site Name	Site Description
AOC-1	Landfarm	During the Stage 2 RI/FS approximately 500 yd^3 of TPH contaminated soils were excavated from Spills No. 2 & 3 and Waste Accumulation Area No. 1 sites and stockpiled east of the access road, directly across from the Composite Facility. Landfarm activities were conducted to reduce TPH concentrations in affected soil throughout the Stage 2 RI/FS. During the 1993 site survey the landfarm was observed to be in poor condition, with no cover to reduce seasonal infiltration and runoff.
AOC-2	POL Line	Previous investigations at Kotzebue LRRS have not included assessment of the fuel line that transferred fuel from the POL (diesel) fuel tanks, formerly located on the beach, to the main facility.
AOC-3	East Tanks	Two above-ground diesel fuel storage tanks, with an estimated capacity of 20,000 gal each, are located on the east side of the access road adjacent to Building 205. The tanks are supported on concrete footings set in a gravel pad, and are contained within a bermed area. The tanks and surrounding area have not been previously assessed, and some limited signs of soil staining directly beneath outlet valves was observed during the 1993 site survey.
AOC-4	Garage/ Power Plant	Stained soils were observed beneath the raised flooring (approx. 4 ft above ground surface) of the power plant and garage area associated with the Composite Facility. It has not been established that floor drains within these areas discharged directly to the ground.
AOC-5	Small Day Tanks	A number of small day tanks (250 gal above ground diesel fuel tanks) were formerly used throughout the installation. Potential diesel fuel releases could have occurred historically due to overfilling or direct release from tanks or tank lines. No previous assessment of these smaller tanks (as a group) has been conducted.
AOC-6	Navigational Aid Bldgs. (101-102)	The navigational aid buildings are located north of the Composite Facility. The navigational aid buildings have been included for assessment based on elevated DROs concentrations in soils identified during a 1993 Environmental baseline survey conducted at Building 101. During the 1993 site survey the buildings were locked and not accessible. The surrounding area did not indicate obvious signs of contamination.
AOC-7	Steel Pilings	This site is identified by steel structure pilings (I-Beams) located east of Building 205, on the east side of the installation's access road. Buildings identified during review of historical aerial photographs suggest that this area was a former construction camp site established during initial radar facility construction.
AOC-8	White Alice Garage	The White Alice garage was reportedly used for storing and servicing site vehicles; no identified releases or hazardous materials storage information has been reported. However, this area has not been previously characterized, and has been recommended for assessment based on past usage of the building. During the 1993 site inspection the building was not accessable for interior inspection. Based on visual observations reported, no obvious signs of contamination were identified.
AOC-9	White Alice Tanks	Two diesel fuel storage tanks, with an estimated capacity of 20,000 gal each, are located at the White Alice Station adjacent to Building 1001. The tanks are presently empty, and tank piping has been disconnected. The tanks are contained within a bermed area and are supported above a gravel base by concrete footings. The tanks are a new area of concern based on reports regarding observed overfilling at outlet valves during previous 611 CES site visits. The 1993 site survey revealed some signs of soil staining directly beneath outlet valves, and an open drum under one of the tank valves was half filled with water, and is assumed to have been used to contain fuel spillage during piping disconnection. The tanks appear to be in good condition, with no observable signs of deterioration.
AOC-10	Septic Holding Tank	The primary sewage treatment of domestic wastewater was provided by a single septic tank located west of the composite facility. Septic tank effluent was discharged into Kotzebue Sound through an outfall line. Shop floor drain wastewater was reportedly discharged to septic tank.

3.7 SITE STATUS IN 1994

Previous IRP investigations identified twelve sites for potential remediation at Kotzebue LRRS. Two sites, Spills No. 2 and 3, were later combined due to the similar nature of contamination (diesel fuel), and because these spills had commingled. Of these 11 sites at Kotzebue LRRS, the USAF recommended that no further action be implemented at eight sites, based on the results of past RIs and remedial actions. The Alaska Department of Environmental Conservation (ADEC) concurred with this recommendation for five of the eight sites, including Sites SS06-Spill/Leak No. 1, SD03-Road Oiling, SS01-Waste Accumulation Area No. 1, SS09-PCB Spill, and SS10-Solvent Spill.

The remaining six initial sites (SS02-Waste Accumulation Area No.2/Landfill; ST05-Beach Tanks; SS07-Lake; SS08-Barracks Pad; SS11-Fuel Spill; SS12-Spills No. 2 and 3) requiring further action, plus the ten areas of concern (AOC1 through AOC10) identified during the September 1993 site survey, and the two areas of concern (AOC11 and AOC12) identified during the 1994 site reconnaissance, totaled 18 sites to be characterized during the 1994 RI.

As a result of the Kotzebue LRRS 1994 Remedial Investigation (discussed in detail in the following sections of this report), a number of areas of concern were formally designated as sites by the USAF, as identified below.

Original AKA Designation	USAF Site Designation	USAF Site Name
AOC1	SS13	Landfarm
AOC3	SS14	East Tanks
AOC4	SS15	Garage/Power Plant
AOC6	SS16	Navigational Aid Buildings
AOC6	SS17	Building 102
AOC9	ST04	White Alice Tanks
AOC11	SS18	Truck Fill Stand
AOC12	SS19	PCBs Spill, South Fence

Site SS17-Building 102 is a 72 square foot area of stained soil, located in a gravel driveway at the Navigational Aid Building (Bldg. 102). Site SS17 was formally identified by the USAF based on the detection of PCB during preliminary field screening in 1994. The area of stained soil comprising Site SS17 is included in the 1994 characterization of Site SS16-Navigational Aid Buildings (see above).

A total of 19 sites and 5 areas of concern are identified at Kotzebue LRRS. Figure 3-1 provides a current summary of all sites and areas of concern investigated at Kotzebue LRRS during the Stage 1 RI/FS, Stage 2 RI/FS, or 1994 RI.

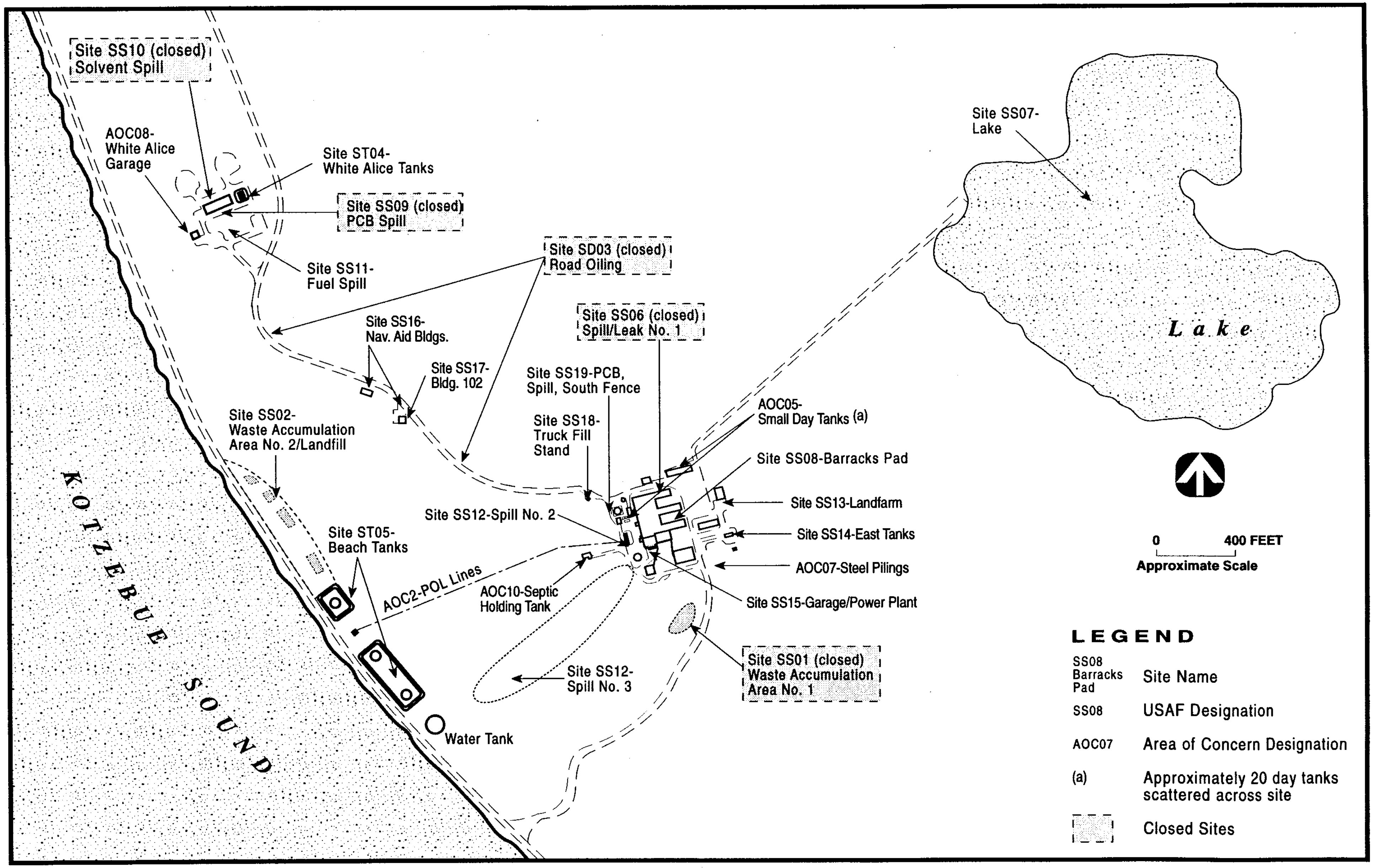

Figure 3-1. Summary of Sites Investigated During Stage 1 RI/FS, Stage 2 RI/FS, or 1994 RI, Kotzebue LRRS, Alaska.

4.0 1994 IRP REMEDIAL INVESTIGATION AT KOTZEBUE LRRS

This section provides a summary of project objectives, applicable or relevant and appropriate requirements that could be applicable to Kotzebue LRRS, and field and sample analysis activities performed at 14 sites and 5 areas of concern during the Kotzebue LRRS 1994 RI. A summary of the status and recommendations for all sites identified at Kotzebue LRRS is provided in Section 7.0, Summary of Site Status and Recommendations. All field investigation and sample analysis activities and methodologies were conducted in accordance with project guidance documents, including the Work Plan (WP), Quality Assurance Project Plan (QAPP), Field Sampling Plan (FSP), and the Health and Safety Plan (USAF 1994a,b,c,d). A detailed description of specific activities and field tasks can be found in the FSP (USAF 1994c). Unless specified, the activities described in the FSP and QAPP conform to guidelines established by the *IRP Handbook*.

4.1 PROJECT OBJECTIVES

The general approach regarding development of the Kotzebue RI/FS was to maximize the use of data from previous site investigations (see Section 3.0, Previous IRP Investigation Activities). The overall site objectives included the collection of all data needed to characterize the site, support the natural biodegradation assessment, complete the site conceptual model, support the baseline risk assessment, better define ARARs, and perform an analysis of remedial alternatives. General site objectives based on identified data needs included the following:

- Establish background concentrations through the collection of background samples for each analysis conducted and media investigated. No background samples were collected for soil, surface water, or groundwater characterization during previous IRP investigations conducted at Kotzebue LRRS.

- Determine the nature and extent of environmental contamination in soil, surface water, and groundwater media at Kotzebue LRRS.

- Collect the data needed to adequately characterize contaminant fate and transport at Kotzebue LRRS.

- Petroleum hydrocarbon contamination linked to past installation operations and activities at Kotzebue LRRS is primarily related to release(s) of middle-distillate fuels such as diesel and jet fuel. Petroleum hydrocarbon contamination was previously characterized by using EPA Method 418.1. Petroleum hydrocarbon characterization to be conducted at Kotzebue LRRS will be measured using diesel range organics analysis (Method AK102) to provide a quantifiable method of determining the magnitude and extent of individual chemicals comprising petroleum hydrocarbons at the installation.

- The petroleum hydrocarbon soil cleanup levels developed and implemented to guide site characterization and remedial action during previous IRP RI/FS activities are not acceptable to ADEC. Petroleum hydrocarbon concentrations remaining in soils at selected sites will require additional characterization to evaluate current site conditions and the extent of potential contamination relative to ADEC accepted criteria. ADEC has established a target level for diesel range organics (DROs) at 1,000 mg/kg in soils for sites located along the tundra hill above the beach area at Kotzebue LRRS.

- Routine analysis of volatile organic compounds (VOC) or semivolatile organic compounds (SVOC) was not performed during previous IRP investigations, preventing a quantitative assessment of potential human or ecological risks. Additional site characterization will incorporate VOC and SVOC analyses to provide a basis for evaluating site risks associated with specific chemicals, and to support further assessment of suitable ARARs.

- The extent to which natural biodegradation may be active, and to what extent it may be responsible for a reduction in contaminant concentrations in groundwater, surface water, and soils will be evaluated.

- Twelve new areas of concern have been identified in addition to the six sites characterized during previous IRP investigations conducted at Kotzebue LRRS. The recently identified areas of concern will be characterized during the field investigation, and will incorporate site survey and historical information regarding past site use.

A phased sampling approach was employed during the 1994 RI to ensure that sites and areas of concern were adequately characterized prior to completion of the field effort. Diesel range organic analysis was conducted by the laboratory on a five day turnaround basis to provide the field team with information regarding the magnitude and extent of petroleum hydrocarbon contamination in site-specific media. This information was used by the field team to guide further site characterization as needed. The phased sampling approach conducted at Kotzebue LRRS included:

1) The initial (limited) collection of environmental samples at identified sites and areas of concern;
2) The review of preliminary DRO results as provided from the laboratory;
3) The mapping of site-specific sample concentrations based on preliminary DRO results; and
4) The determination of additional site characterization needs based on review of initial site DRO contaminant distribution.

Data needs identified by the field investigation team during course at the RI were communicated to the AFCEE and 611th CES for concurrence prior to conducting addition site characterization.

4.2 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Applicable or relevant and appropriate requirements (ARARs) include statutes established by EPA and other federal agencies, and those established by the State of Alaska, if the Alaska standards are more stringent than the federal standards. These requirements, in addition to the health-based standards established in the Baseline Risk Assessment, form the preliminary remediation goals for developing cleanup alternatives for the site. ARARs are one of two threshold criteria that must be met, the other being overall protection of human health and the environment, in order for an alternative to be selected as the final remedy for a site.

The EPA has defined what constitutes an ARAR as those promulgated regulations that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site. Promulgated requirements are those laws and regulations that are of general applicability and are legally enforceable. EPA specifically states in the ARAR guidance document [Section 120 of CERCLA (10 USC 2701 et seq.)], that nonpromulgated advisories and guidance documents issued by federal or state governments do not have the status of potential ARARs, but may be used to determine the level of cleanup necessary to protect human health and the environment. For a regulation to be applicable, it must satisfy all jurisdictional prerequisites of the requirement.

A regulation may be relevant and appropriate, even if it is not applicable as defined above. According to EPA, relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements that address problems or situations sufficiently similar to those encountered at a CERCLA site. Kotzebue LRRS is not on the National Priorities List of ranked CERCLA sites; however, the use of these requirements is appropriate at Kotzebue LRRS, as the identification of ARARs is a critical part of the RI/FS process.

EPA classifies ARARs into three groups:

Chemical Specific:	Ambient or chemical-specific requirements that set concentration limits for an element or chemical compound in various environmental media such as ambient water, drinking water, ambient air, soil, or solid waste.
Action Specific:	Performance, design, or technical requirements (e.g., regulations for the closure of hazardous waste landfills), RCRA incineration standards, RCRA land disposal restrictions, and pretreatment standards for discharges to Publicly Owned Treatment Works (POTWs).
Location Specific:	Location-specific requirements or siting restrictions (e.g., industrial vs. residential properties, native vs. disturbed tundra, etc.).

Chemical specific requirements set health or risk-based concentration limits or ranges in various environmental media for specific hazardous substances, pollutants, or contaminants. Action or location specific

regulations are applicable if industrial processes or remedial actions include the generation, transport, treatment, or disposal of regulated hazardous wastes or contaminated environmental media.

4.2.1 Summary of Detected Contaminants

Table 4-1 lists the contaminants and the media they were detected in at Kotzebue LRRS during the 1994 RI. The maximum concentrations of contaminants detected in soil, sediment, surface water, and groundwater samples collected during 1994 RI are presented in Section 4.5, Summary of Analytical Results. The identification of ARARs addressing chemical-specific requirements were based on the reported detections of contaminants during the 1994 RI. Maximum contaminant concentration data have been used, in part, to further refine the list of potential ARARs.

4.2.2 Identification of ARARs

The potential ARARs listed in Tables 4-2 and 4-3 represent a thorough search of federal and state regulations for applicable or relevant and appropriate requirements that could be applicable to Kotzebue LRRS. These have been screened to select or exclude specific requirements, based on the site-specific activities at Kotzebue LRRS. The following is a list of federal and state statutes and regulations that were selected to serve as ARARs for Kotzebue LRRS. Some ARARs listed below contain specific sections, chapters, or parts that are relevant to a specific contaminant, location, or remedial process.

Federal ARARs

- Clean Water Act (CWA)
- Clean Air Act (CAA)
- Occupational Safety and Health Act (OSHA)
- Endangered Species Act (ESA)
- Coastal Zone Management Act (CZMA)
  - Executive Order #11990 on Protection of Wetlands
  - Executive Order #11998 on Protection of Floodplains
- Toxic Substances Control Act (TSCA)
- Migratory Bird Treaty Act of 1972
- Marine Mammal Protection Act

TABLE 4-1. SUMMARY OF DETECTED COMPOUNDS,
1994 REMEDIAL INVESTIGATION, KOTZEBUE LRRS, ALASKA
(Page 1 of 2)

Analytical Parameter	Environmental Media			
	Soil	Sediment	Surface Water	Groundwater
Volatile Organics				
1,1,2-Trichloro-1,2,2-trifluoroethane	●	●	○	○
Acetone	●	●	●	●
Benzene	●	○	○	●
Carbon Disulfide	○	○	○	●
Chlorobenzene	●	○	○	○
Chloroform	●	○	○	●
cis-1,2-Dichloroethylene	●	○	○	○
Ethylbenzene	●	●	○	●
Methyl Ethyl Ketone (2-butanone)	●	●	●	●
Methylene Chloride	●	●	●	○
Tetrachloroethylene (pce)	●	○	○	○
Toluene	●	●	○	●
Trichloroethylene (tce)	●	○	○	●
Xylenes, total	●	●	○	●
Semivolatile Organics				
1,3-Dichlorobenzene	○	○	●	●
1,4-Dichlorobenzene	●	○	○	○
2-Methylnaphthalene	●	○	○	●
2-Nitroaniline	●	●	○	○
4-Chloroaniline	●	○	○	○
4-Methylphenol	●	●	●	●
4-Nitrophenol	●	●	○	○
Acenaphthene	●	●	○	●
Acenaphthylene	○	○	○	●
Anthracene	●	○	○	○
Benzo(a)anthracene	●	○	○	○
Benzo(a)pyrene	●	○	○	○
Benzo(b)fluoranthene	●	○	○	○
Benzoic Acid	●	●	○	●
bis(2-Ethylhexyl) Phthalate	●	●	●	●
Butylbenzylphthalate	●	○	○	○
Chrysene	●	○	○	○
di-n-butyl Phthalate	●	○	○	○
di-n-Octylphthalate	○	○	○	●
Dibenzofuran	●	○	○	●
Dimethyl Phthalate	●	○	○	○
Fluoranthene	●	○	○	○
Fluorene	●	○	○	●
Isophorone	●	●	●	○

TABLE 4-1. SUMMARY OF DETECTED COMPOUNDS,
1994 REMEDIAL INVESTIGATION, KOTZEBUE LRRS, ALASKA
(Page 2 of 2)

Analytical Parameter	Environmental Media			
	Soil	Sediment	Surface Water	Groundwater
Semivolatile Organics (Cont.)				
Naphthalene	●	○	○	●
Phenanthrene	●	○	○	●
Phenol	●	○	○	●
Pyrene	●	○	○	○
Pesticides/PCBs				
4,4'-DDD	●	●	●	●
4,4'-DDE	●	●	●	●
4,4'-DDT	●	●	●	●
Aldrin	●	●	●	○
alpha BHC	●	●	●	○
alpha-Chlordane	●	●	○	○
Arochlor 1254	●	●	○	○
Arochlor 1260	●	●	○	○
beta BHC	●	○	●	○
delta BHC	●	●	●	○
Dieldrin	●	●	●	○
Endosulfan I	●	○	○	○
Endosulfan Sulfate	○	○	●	○
Endrin	●	●	○	○
Endrin Aldehyde	●	○	○	○
gamma BHC (Lindane)	●	●	○	○
gamma-Chlordane	●	●	○	○
Heptachlor	●	○	●	○
Heptachlor Epoxide	●	●	●	○
Methoxychlor	●	●	○	○
Metals[a]				
Barium	○	○	●	○
Calcium	●	●	●	○
Iron	○	○	●	●
Lead	●	●	○	○
Magnesium	○	○	●	○
Manganese	○	○	●	●
Potassium	○	○	●	●
Sodium	○	○	●	○
Zinc	○	●		○
Petroleum Hydrocarbons	●	●	●	●

○ = Not detected. ● = Detected.

[a] Metals Analysis: Inorganic compounds listed are those compounds detected at or above three times their mean background concentrations.

TABLE 4-2. FEDERAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS) FOR REMEDIAL INVESTIGATION/FEASIBILITY STUDY AT KOTZEBUE LRRS
(Page 1 of 4)

Federal Statute	Regulation	Description	Chemical Specific	Location Specific	Action Specific*	Preliminary Rationale for Selection or Exclusion
Safe Drinking Water Act (SDWA), National Primary Drinking Water Regulations	42 USC Section 300(f); 40 CFR Part 141	Establishes standards for current and potential drinking water supplies by setting maximum contaminant levels (MCLs) and non-zero maximum contaminant level goals (MCLGs).	X			EXCLUDED-There are no drinking water supplies within 3 miles of the installation. Near-beach groundwater is non-potable (brackish).
Federal Water Pollution Control Act [Clean Water Act (CWA)]	33 USC Section 1251-1376	Effluent discharge standards, ocean discharge requirements, and water quality criteria.	X		X	SELECTED-Water quality criteria are applicable.
CWA	40 CFR Part 122 & 125	Establishes the NPDES program which requires the permitting of a point discharge into marine or surface waters of the U.S. in Alaska; the NPDES program is administered by U.S. EPA Region 10.	X	X	X	EXCLUDED-No remedial actions involving point discharge into marine or surface waters are under consideration.
CWA	40 CFR Part 129	Establishes toxic pollutant effluent standards or prohibitions for certain toxic pollutants; aldrin/dieldrin, DDT/DDD/DDE, endrin, toxaphene, benzidine, and PCBs.	X		X	EXCLUDED based on contaminants of concern detected in groundwater.
CWA	40 CFR Part 131	Establishes water quality criteria based on toxic effects on human health and aquatic life.	X			SELECTED-Applicable criteria for the protection of aquatic life and risk evaluation.
CWA	Section 404	Requires that actions must be taken to avoid adverse effects in wetlands and prohibits discharges to wetlands.		X	X	SELECTED-Wetlands are situated in the general vicinity of sites.
CWA	Section 402; 42 CFR Part 1342	Establishes effluent standards to ensure state ambient water quality standards are met in receiving waters.	X			SELECTED-Potential basis for remediation criteria for surface waters.
Clean Air Act (CAA)	42 USC Sections 7401-7602; 40 CFR Part 50	Establishes standards for national ambient air quality necessary to protect human health and welfare.	X		X	SELECTED-May be applicable depending on the remedial technologies selected.
CAA	40 CFR Part 61	Establishes national emission standards for hazardous air pollutants (NESHAP).	X			EXCLUDED-No hazardous air pollutants were identified.
Resource Conservation and Recovery Act (RCRA)	40 CFR Part 261	Sets standards for determining if a waste is a hazardous waste.	X			EXCLUDED-Hazardous wastes were not detected in site sampling activities.
RCRA	40 CFR Part 261, Subpart C, Sect. 261.24	Defines hazardous waste by use of toxicity characteristics leaching potential test.	X			EXCLUDED-Hazardous wastes were not detected in site sampling activities.
RCRA	40 CFR Parts 264 and 265, Subparts A-E	Requires persons treating, storing, or disposing of hazardous waste meet set of facility standards, draft a contingency plan, and meet recordkeeping/reporting standards.			X	EXCLUDED-Hazardous wastes were not detected in site sampling activities.
RCRA	40 CFR Parts 264 and 265, Subpart I	Sets standards for persons storing or treating hazardous waste in containers.			X	EXCLUDED-Hazardous wastes were not detected in site sampling activities.

TABLE 4-2. FEDERAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS) FOR REMEDIAL INVESTIGATION/FEASIBILITY STUDY AT KOTZEBUE LRRS
(Page 2 of 4)

Federal Statute	Regulation	Description	Chemical Specific	Location Specific	Action Specific*	Preliminary Rationale for Selection or Exclusion
RCRA	40 CFR Parts 264 and 265, Subpart J	Sets standards for persons storing or treating hazardous waste in tanks.			X	EXCLUDED-Hazardous wastes were not detected in site sampling activities.
RCRA	40 CFR Parts 264 and 265, Subpart L	Establishes regulations for persons storing or treating hazardous waste in piles.			X	EXCLUDED-Hazardous wastes were not detected in site sampling activities.
RCRA	40 CFR Parts 264 and 265, Subpart O	Establishes regulations for persons treating hazardous waste in incinerators.			X	EXCLUDED-Hazardous wastes were not detected in site sampling activities. On-site incineration not considered as remedial alternative.
RCRA	40 CFR Part 268	Identifies hazardous wastes restricted from land disposal.	X		X	EXCLUDED-Hazardous wastes were not detected in site sampling activities.
RCRA	40 CFR Parts 268, Subpart D	Requires hazardous waste to be treated to specific standards before it can be landfilled.	X		X	EXCLUDED-Hazardous wastes were not detected in site sampling activities.
RCRA	40 CFR Part 270	Establishes regulations which include permitting requirements for facilities that treat, store, or dispose of hazardous wastes.	X		X	EXCLUDED-Hazardous wastes were not detected in site sampling activities.
RCRA	--	Establishes regulation that new treatment, storage, or disposal of hazardous waste is prohibited within the 100-year floodplain.		X	X	EXCLUDED-Hazardous wastes were not detected in site sampling activities.
Occupational Safety and Health Act (OSHA)	29 CFR 1910	Establishes requirements applicable to worker exposures during response actions at RCRA and CERCLA sites.		X		SELECTED-Applicable for all field work performed.
Fish & Wildlife Coordination Act (FWCA)	16 USC Section 661-666; 40 CFR Part 6, Subpart C, Sect. 6.302(g); 33 CFR Parts 320-330	Requires consultation when federal agency proposes/ authorizes modifications to streams or other water bodies (including wetlands) to provide adequate protection of fish/wildlife resources and to take actions to prevent loss or damage to these resources.		X	X	EXCLUDED-No waterbodies (including wetlands) will be modified.
Endangered Species Act (ESA)	16 USC Sections 1531-1543	Requires that federal agencies ensure that any action authorized, funded, or carried out by the agency is not likely to jeopardize the continued existence of any threatened/ endangered species, or destroy or adversely modify critical habitat.		X	X	SELECTED-No threatened/ endangered species are identified. However, wetlands may be considered a critical habitat.
ESA	40 CFR Part 6, Subpart C, Sect. 6.302 (h)	If a listed species is present, a biological assessment is required to examine any possible impacts upon the species or habitat.		X	X	EXCLUDED-No listed species are present.

TABLE 4-2. FEDERAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS) FOR REMEDIAL INVESTIGATION/FEASIBILITY STUDY AT KOTZEBUE LRRS
(Page 3 of 4)

Federal Statute	Regulation	Description	Chemical Specific	Location Specific	Action Specific*	Preliminary Rationale for Selection or Exclusion
Coastal Zone Management Act (CZMA)	16 USC Sections 1451-1464	Prohibits federal agencies from undertaking any activity in or affecting a state's coastal zone that is not consistent with the state's approved CZMA program. Coastal zones are identified as "coastal waters and the adjacent shorelines strongly influenced by each other" and includes the water and lands therein and thereunder.		X	X	SELECTED-Remedial actions conducted at site(s) along Kotzebue Sound will require consideration of CZMA statute.
Wild & Scenic Rivers Act (WSRA)	36 CFR Part 297	Federal agencies may not assist in construction of water resources projects that would have direct and adverse effect on free-flowing scenic, natural, recreational, fish and wildlife values for which a river on the system or inventory was established. Indirect effects from above or below rivers and on adjacent shorelines are also covered. Projects include dams, water conduits, discharge to waters, dredging, and shoreline development.		X	X	EXCLUDED-No water resource project relating to this project will be constructed at Kotzebue LRRS.
Rivers & Harbors Act of 1989	33 USC Section 403 33 CFR Parts 320-330	Requires Section 10 permits for structures or work in or affecting navigable waters.		X	X	EXCLUDED-No structures or work in or affecting navigable waters (Kotzebue Sound) is anticipated.
Executive Order #11990 on Protection of Wetlands	EO #11990 and 40 CFR Part 6, Subpart C, Sect. 6.302(a) and Appendix A	Requires federal agencies to avoid the adverse impacts associated with the destruction or loss of wetlands; to avoid new construction in wetlands if alternatives exist; and to develop mitigative measures if adverse impacts are unavoidable.		X	X	SELECTED-Wetlands are situated in the general vicinity of sites.
Executive Order #11988 on Protection of Floodplains	EO #11988 and 40 CFR Part 6, Subpart C, Sect. 6.302(b) & Appendix A	Requires federal agencies to evaluate the potential effects of actions they may take in a floodplain to avoid the adverse impacts associated with direct and indirect development of a floodplain.			X	SELECTED-Beach area at Kotzebue LRRS may be considered located in a coastal flood hazard zone.
Marine Protection, Research & Sanctuaries Act (MPRSA)	33 USC Parts 1401-1445	Prohibits dumping into the ocean any material that adversely affects the marine environment.			X	EXCLUDED-No remediation alternatives will involve ocean dumping,
Toxic Substances Control Act (TSCA)	40 CFR Part 761	Establishes storage, disposal, and spill clean-up requirements for PCBs.	X		X	SELECTED-PCBs detected in soil and sediment.
Migratory Bird Treaty Act of 1972	16 USC Sections 703-708-, 109a-711	Provides protection for almost all native birds in the U.S. from unregulated and unintentional "take", which includes poisoning from hazardous wastes.			X	SELECTED-No significant risk to migratory birds has been identified at sites. Remedial actions will require consideration of this act.

TABLE 4-2. FEDERAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS) FOR REMEDIAL INVESTIGATION/FEASIBILITY STUDY AT KOTZEBUE LRRS
(Page 4 of 4)

Federal Statute	Regulation	Description	Chemical Specific	Location Specific	Action Specific*	Preliminary Rationale for Selection or Exclusion
Marine Mammal Protection Act	16 USC Section 1374	Provide protection for almost all marine mammals in the U.S. from unregulated and unintentional "take", which includes poisoning from hazardous wastes and human disturbances.		X	X	SELECTED-No significant risk to marine mammals has been identified at sites. Remedial actions will require consideration of this act.
Fish & Wildlife Conservation Act of 1980	16 USC Section 1901 and 50 CFR Part 83	Provide for consideration of impacts on wetlands, protected habitats, and fisheries.		X	X	SELECTED-May apply depending on remedial actions conducted.
Wilderness Act	16 USC Section 1131 -et seq.	Establishes the Wilderness Preservation Systems in order to preserve the wilderness character of these units and leave them unimpaired for future uses; compliance with prohibitions on activities in the wilderness area is required.		X	X	EXCLUDED-Kotzebue LRRS is not a designated wilderness preservation system.
National Historical Preservation Act	16 USC 470 et seq; 36 CFR Part 800	Prohibits the alteration of terrain that threatens significant scientific, prehistorical, historical, or archaeological data; action to recover and preserve artifacts.		X	X	SELECTED-Native American artifacts may exist within installation boundaries.

* Selection/Exclusion rationale is dependent on future actions.

TABLE 4-3. STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS) FOR REMEDIAL INVESTIGATION/FEASIBILITY STUDY AT KOTZEBUE LRRS (Page 1 of 2)

Title 18. Environmental Conservation	State Regulation	Description	Chemical Specific	Location Specific	Action Specific*	Preliminary Rationale for Selection or Exclusion
Air Quality Control (AQC) Chapter 50	18 AAC 50.010-18 AAC 50.900	Sets standards for air quality control	X	X	X	SELECTED-Potentially applicable depending on remedial technologies selected.
Solid Waste Management (SWM) Chapter 60	18 AAC 60.010- 18 AAC 60.910	Sets standards for solid waste management	X	X	X	SELECTED-May be applicable for certain remedial actions.
SWM	18 AAC 60.15	Sets criteria for long-term storage of solid waste on-site			X	SELECTED-May be applicable if contaminated material is stored on-site.
SWM	18 AAC 60.025	Sets criteria for the transportation of a solid waste			X	SELECTED-May be applicable if contaminated media are transported off-site.
SWM	18 ACC 60.75	Sets guidelines for landspreading, a passive remedial technology			X	SELECTED-May be applicable if landspreading is implemented as a remedial technology.
Hazardous Waste (HW) Chapter 62	18 AAC 62.010- 18 AAC 62.990	Sets standards for handling and disposal of hazardous waste	X		X	EXCLUDED-Hazardous wastes were not detected in site sampling activities.
Water Quality Standards (WQS) Chapter 70	18 AAC 70.010- 18 AAC 70.910	Sets standards for water quality	X		X	SELECTED-Water Quality Standards will regulate sites at Kotzebue LRRS.
WQS	18 AAC 70.020	Sets standards for the control of toxic wastes into fresh and marine waters			X	SELECTED-Criteria will apply to sites at Kotzebue LRRS.
WQS	18 AAC 70.022 (Proposed revision)	Set water quality criteria for carcinogenic substances for the protection of human health			X	SELECTED-Criteria may be applicable to sites at Kotzebue LRRS.
WQS	18 AAC 70.025	Modification of water quality standards based on site specific criteria			X	SELECTED-May be applicable based on conditions characterized at Kotzebue LRRS.
Oil and Hazardous Substances Pollution Control (OHPC) Chapter 75	18 AAC 75.010- 18 AAC 75.990	Sets regulations for oil and hazardous substances pollution control	X	X	X	SELECTED-Applicable for remediation of sites.
OHPC 18 AAC75.140	Interim guidance for non-UST petroleum contaminated soils	General guidelines establishing cleanup levels for petroleum hydrocarbon spills		X	X	EXCLUDED-ADEC indicates not applicable at Kotzebue LRRS.
OHPC 18 AAC 75.140	Guidance for storage, remediation, and disposal of non-UST petroleum contaminated soils	Comprehensive guidance for the storage, treatment, and disposal of non-UST petroleum contaminated soil			X	SELECTED-May be applicable for remediation of petroleum contaminated sites at Kotzebue LRRS.
OHPC 18 AAC 75.140	Interim guidance for surface and groundwater cleanup levels	Sets cleanup standards for contaminated surface soils and groundwater remediation			X	SELECTED-May provide alternative for developing cleanup standards.

TABLE 4-3. STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS) FOR REMEDIAL INVESTIGATION/FEASIBILITY STUDY AT KOTZEBUE LRRS
(Page 2 of 2)

Title 18. Environmental Conservation	State Regulation	Description	Chemical Specific	Location Specific	Action Specific*	Preliminary Rationale for Selection or Exclusion
OHPC	18 AAC 75.300	Discharge notification requirement for discharge of any hazardous substances			X	EXCLUDED-Hazardous wastes were not detected in site sampling activities.
OHPC	18 AAC 75.319	Disposal approval of hazardous substances			X	EXCLUDED-Hazardous wastes were not detected in site sampling activities.
OHPC	18 AAC 75.327	Requirements for containment, cleanup, and disposal of hazardous substances discharged into the environment			X	EXCLUDED-Hazardous wastes were not detected in site sampling activities.
Drinking Water Chapter 80	18 AAC 80.010-18 AAC 80.900	Sets standards for Drinking Water	X	X	X	SELECTED-There are no drinking water sources within 3 miles of the installation; however, drinking water standards may apply based on water quality standards criteria.

* Selection/Exclusion rationale is dependent on future actions.

- Fish And Wildlife Conservation Act of 1980
- National Historical Preservation Act

Alaska State Regulations

- Air Quality Control (AQC)
- Solid Waste Management (SWM)
- Water Quality Standards (WQS)
- Drinking Water Standards (DRS)
- Oil and Hazardous Substances Pollution Control (OHSPC)
  - Guidance for Storage, Remediation, and Disposal of Non-UST Petroleum Contaminated Soils
  - Interim Guidance for Surface and Groundwater Cleanup Levels

4.2.3 Cleanup Guidelines for Kotzebue LRRS

State and federal regulatory criteria pertinent to Kotzebue LRRS for the development of water quality and soil cleanup guidelines are discussed in the following sections.

4.2.3.1 Water Quality. ADEC considers sites at Kotzebue LRRS regulated under Water Quality Standards Regulation (18 AAC 70; January 1995), based on the presence of petroleum hydrocarbons at the site, and the potential for petroleum hydrocarbon migration to surface water and near-beach groundwater adjacent to the facility. A detailed description of surface water and groundwater occurrence at Kotzebue LRRS is provided in Section 2.0, Environmental Setting. There are no drinking water source(s) within 3 miles of the installation. Near-beach groundwater at Kotzebue LRRS is saline (brackish) in nature, is tidally influenced, and represents a non-potable resource. Drinking water is supplied by the City of Kotzebue through the use of Devil's and Vortac Lakes, located near the town, as municipal water supply sources (USAF 1990a). Federal Drinking Water Standards are not considered applicable at Kotzebue LRRS. However, ADEC Drinking Water Standards may be applicable as they relate to state water quality standards for fresh water recreational use (18 AAC 70.020; January 1995).

The EPA has established numerical water quality standards for priority pollutants for the State of Alaska, including acute and chronic water quality criteria for toxic substances found in fresh and saltwater

environments for the protection of aquatic life. Additionally, human health criteria has been recommended based on water concentration criteria for the protection of human health from the consumption of contaminated water, fish, and/or shellfish (EPA 1992). The EPA indicates the human health criteria shall be applied at the 10^{-5} risk level, consistent with state policy (EPA 1992). The EPA-recommended criteria for toxics have undergone several changes, which have resulted in a variety of criteria for each toxic substance. The EPA published the "gold book" of recommended criteria in 1986 (EPA 1986). These recommended criteria have been updated in a number of Federal Register notices and documents published by the EPA through 1988. In 1991, EPA released a poster of updated water quality criteria with a reference to *Quality Criteria for Water—1992*, a "silver book" which has not yet been released to the public. In December 1991, the EPA published the "final toxics rule" which promulgated water quality criteria for 126 priority pollutants for states (including Alaska) that did not have EPA-approved water quality criteria (EPA 1992).

4.2.3.2 Soil. Petroleum hydrocarbon contamination linked to past installation operations and activities is the primary environmental problem identified at Kotzebue LRRS. ADEC has indicated that the use of Interim Guidance for Non-UST Contaminated Soil Cleanup Levels, dated July 17, 1991, is not applicable for developing soil cleanup levels at petroleum contaminated sites at Kotzebue LRRS due to the occurrence and potential for petroleum hydrocarbon migration to surface water and near-beach groundwater at the facility. However, ADEC has established a soil target level for petroleum hydrocarbon (diesel range organics) contaminated soil at 1,000 mg/kg, to assist in the definition of the lateral and vertical extent of petroleum hydrocarbon contaminated soil associated with sites above the beach area at Kotzebue LRRS (Noland, L., February 1994, Personal Communication).

PCBs (Aroclor 1254 and 1260) were detected in a limited number of soil samples at relatively low concentrations during the 1994 RI. ADEC has deferred the regulation of PCB spills in Alaska to the EPA (Region 10). In 1987, the EPA Region 10 established a PCB cleanup policy which applies to intentional and accidental spills of material containing at least 50 mg/L PCB (Federal Register Vol. 52, pg. 10688). The policy establishes separate cleanup requirements for low concentrations (i.e., 50 to 500 mg/L) spills involving less than one pound of PCB by weight, and high concentrations (>500 mg/L) spills involving more than one pound of PCB by weight. The regulation states that when a low concentration PCB spill involving less than one pound of PCB occurs in a nonrestricted access area, visibly contaminated soils and a buffer of one lateral foot around the visible traces must be removed and the excavation backfilled

with clean soil. When a high or low concentration PCB spill of more than one pound of PCB by weight occurs in a nonrestricted access area, soil containing more than 10 mg/kg PCB by weight must be removed, provided that soil is excavated to a minimum depth of 10 inches and the excavation is backfilled with clean soil. For spills that occurred before April 2, 1987, cleanup levels are typically established by the EPA regional offices on a case-by-case basis. Limited information is available regarding past PCB spills at Kotzebue LRRS. Previous IRP investigation at Kotzebue LRRS have established PCB target cleanup levels at 10 mg/kg based on EPA Region 10 PCB Cleanup Policy (EPA 1987).

4.3 ANALYTICAL PROGRAM

This section provides a summary of the sample analyses and QA/QC activities conducted during the 1994 RI. Data reduction, validation, and reporting activities conducted in support of the 1994 RI are also discussed. Fourteen sites and five areas of concern were investigated during the 1994 RI as identified below:

- Site SS02-Waste Accumulation Area No.2/Landfill
- Site ST04-White Alice Tanks (AOC9)
- Site ST05-Beach Tanks
- Site SS07-Lake
- Site SS08-Barracks Pad
- Site SS11-Fuel Spill
- Site SS12-Spills No.2 and 3
- Site SS13-Landfarm (AOC1)
- Site SS14-East Tanks (AOC3)
- Site SS15-Garage/Power Plant (AOC4)
- Site SS16-Navigational Aid Buildings (AOC6)
- Site SS17-Building 102 (AOC6)
- Site SS18-Truck Fill Stand (AOC11)
- Site SS19-PCB Spill South Fence (AOC12)
- AOC2-POL Line
- AOC5-Small Day Tanks
- AOC7-Steel Pilings
- AOC8-White Alice Garage
- AOC10-Septic Holding Tank

Figure 4-1 identifies the 14 sites and 5 areas of concern investigated during the 1994 RI. A summary of site-specific field activities conducted at Kotzebue LRRS during the 1994 RI is provided in Table 4-4. Field activities conducted at Site SS17 were included in the characterization of Site SS16.

4.3.1 Sample Analyses Summary

The analytical program for samples collected at Kotzebue LRRS during the 1994 RI supported: 1) a contaminant assessment, 2) a natural biodegradation assessment, and 3) a fate and transport assessment. A detailed description of each analytical method conducted is provided in the QAPP (USAF 1994b).

4.3.1.1 Contaminant Assessment. Analyses conducted on samples from the 14 sites, 5 areas of concern, and the background stations are summarized in Table 4-5, including the number of samples for each media; sample type; the number of analyses and analytical methods for each sample; and the distribution of QA/QC samples. Analyte selection for Kotzebue LRRS sampling sites was determined by evaluating previous IRP site characterization data on suspected and potential hazardous substances associated with historical use and operations. A brief discussion of the rationale for the selection of analytical methods is provided below.

Residual Range Organics (Method AK102-Extended)--Petroleum hydrocarbons were characterized during previous IRP investigations by using EPA Method 418.1. However, no background concentrations were established for the media sampled. Evaluation of existing data suggested that the Method 418.1 measurements did not necessarily define diesel fuel contamination at Kotzebue LRRS. Petroleum hydrocarbon contamination at Kotzebue LRRS from past operations was documented by releases of middle distillates (primarily diesel fuel and jet fuels). For this reason, DROs were measured at Kotzebue LRRS to quantify the extent of petroleum contamination. At sites where waste oils were potentially present (e.g., SS02-Waste Accumulation Area No. 2/Landfill, AOC1-Landfarm, AOC4-Power Plant/ Garage, and AOC8-White Alice Garage), Method AK102 was extended to quantify residual range organics (RROs) between C28 and C40.

Diesel Range Organics (Method AK102)--Method AK102, which measures DROs, was selected to characterize petroleum hydrocarbon contamination at most Kotzebue LRRS sites and AOCs. Diesel

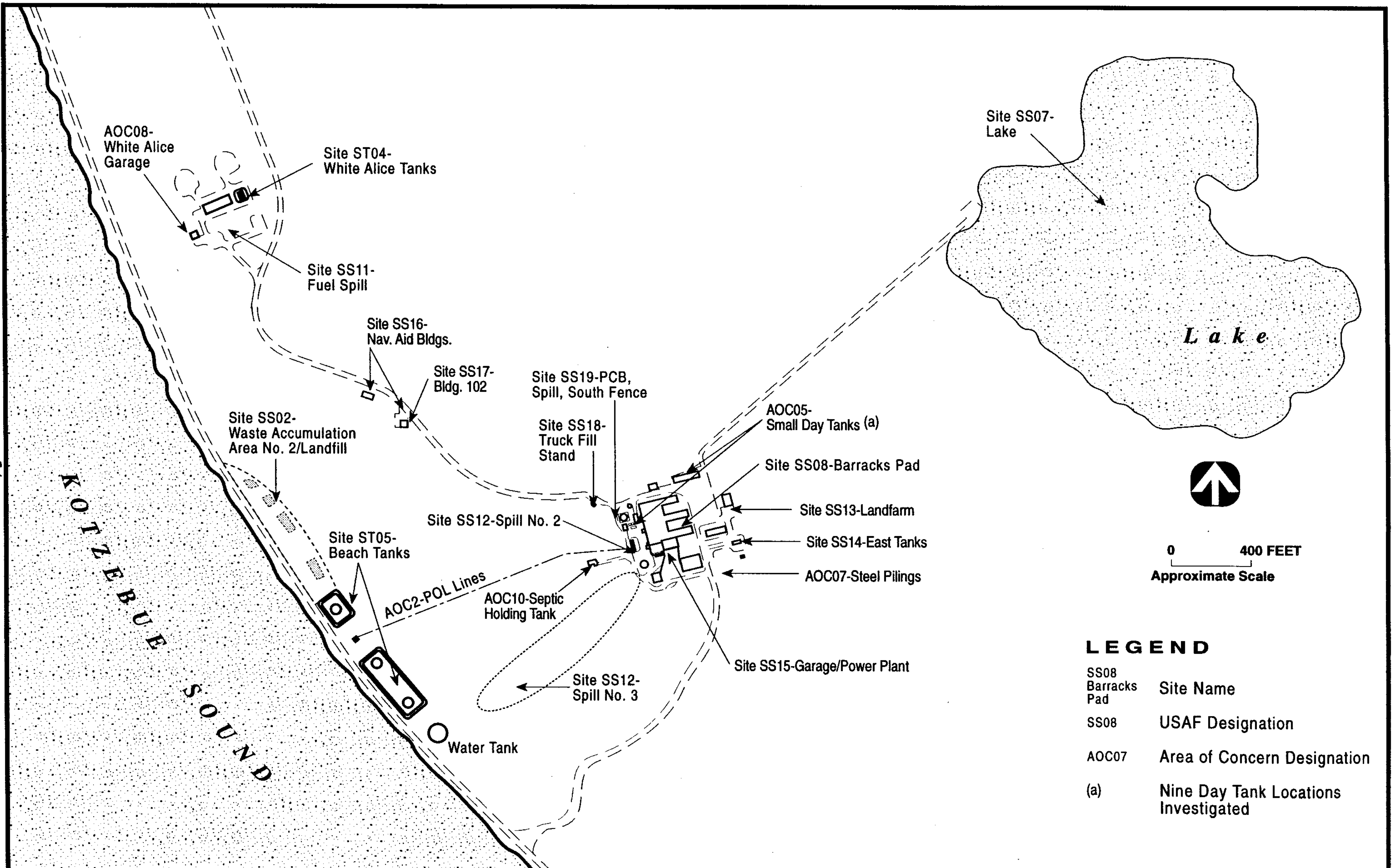

Figure 4-1. Sites and Areas of Concern Investigated During 1994 Remedial Investigation at Kotzebue LRRS, Alaska.

TABLE 4-4. SUMMARY OF FIELD ACTIVITIES CONDUCTED DURING 1994 REMEDIAL INVESTIGATION AT KOTZEBUE LRRS, ALASKA

Site Designation	Facilities Inspection	Field Screening	Hand Auger Sampling	Drilling and Sampling	Installing Wells	Groundwater Sampling	Surface Water Sampling	Seawater Sampling	Free Product Assessment	Tidal Influence	Aquifer Testing	Geotechnical Parameters	Gradiometer Survey	Sample Location Surveying
SS02-Waste Area No. 2/Landfill		●		●	●	●			●			●	●	●
ST05-Beach Tanks		●		●	●	●		●	●	●	●	●		●
SS07-Lake		●	●				●							●
SS08-Barracks Pad		●	●											●
SS11-Fuel Spill		●	●											●
SS12-Spills No. 2 and 3		●	●	●	●	●	●					●		●
SS13-Landfarm (AOC1)		●	●											●
AOC2-POL Lines		●	●											●
SS14-East Tanks (AOC3)		●	●											●
SS15-Power Plant/Garage (AOC4)	●	●	●									●		●
AOC5-Small Day Tanks		●	●											●
SS16-Nav. Aid Bldgs. (AOC6)	●	●	●											●
AOC7-Steel Pilings		●	●									●		●
AOC8-White Alice Garage	●	●	●									●		●
ST04-White Alice Tanks (AOC9)		●	●											●
AOC10-Septic Holding Tank	●	●												●
SS18-Truck Fill Stand (AOC11)		●	●											●
SS19-PCB Spill South Fence (AOC12)		●	●											●
Background Characterization		●	●	●	●	●	●	●						

TABLE 4-5. FIELD SAMPLING AND ANALYSES SUMMARY FOR 1994 REMEDIAL INVESTIGATION AT KOTZEBUE LRRS, ALASKA

			Analytes and Methods						
Site Designation	Media	Number of Samples	Gasoline Range Organics (AK101)	Diesel Range Organics (AK102)	Residual Range Organics (AK102 Extended)	Volatile Organics (8260)	Semivolatile Organics (8270)	Pesticides/PCBs (8081)	Metals (6000, 7000 Series)
SS02-Waste Area No. 2/Landfill	Soil	3		3	1	3	3	3	3
	Groundwater	3	NA[a]	3		3	3	3	6
	Surface Water	1		1		1	1	1	2
ST05-Beach Tanks	Sediment	27		24	1	11	11	3	
	Groundwater	9	NA	9		9	9		NA
	Seawater	3		3		3	3		
SS07-Lake	Sediment	3		3	1	1	3	3	2
	Surface Water	3	NA	3		1	3	3	2
Lake Access	Soil	2						2	
SS08-Barracks Pad	Soil	4	NA	4	1	4	4	4	2
SS11-Fuel Spill	Surface Water	1		1		1	1	1	
	Soil	5	NA	4	NA	4	4	4	NA
	Sediment	1		1		1	1	1	
SS12-Spills No. 2 and 3	Soil	38		38		11	11	10	
	Sediment	2	NA	2	NA	2	2	2	NA
	Surface Water	4		4		4	4	4	
SS13-Landfarm (AOC1)	Soil	6		6	2	3	3	3	2
	Soil	7	NA	7		4	4	4	2
	Surface Water	1		1		1			
AOC2-POL Lines	Soil	3	NA	3	NA	3	3	3	NA
SS14-East Tanks (AOC3)	Soil	7	3	7	NA	3	3	3	NA
SS15-Power Garage/Plant (AOC4)	Soil	8	5	8	1	5	5	5	3
AOC5-Small Day Tanks	Soil	23	NA	23	NA	12	12	12	NA
SS16-Nav. Aid Buildings (AOC6)[b]	Surface Water	1		1		1	1	1	1
	Soil	6	NA	6	2	4	4	4	2
	Sediment	1		1		1	1	1	1
AOC7-Steel Pilings	Soil	3	NA	3	NA	3	3	3	2
AOC8-White Alice Garage	Soil	4	4	4	NA	4	4	4	2
ST04-White Alice Tanks (AOC9)	Soil	4	NA	4	NA	3	3	3	NA
AOC10-Septic Holding Tank	Sediment	1	NA	1	1	1	1	1	1
SS18-Truck Fill Stand (AOC11)	Soil	7	7	7	NA	2	NA	NA	2
SS19-PCB Spill South Fence (AOC12)	Soil	1	NA	1	NA	1	1	1	NA
Background Characterization	Soil	4	3	4		4	4	4	4
	Lake Sediment	3		3	1	3	3	3	3
	Beach Sediment	3		3		3	3	3	3
	Groundwater	1		1		1	1	1	2
	Surface Water	3		3		3	3	3	6
	Sea Water	1		1		1	1		
Total Number of Environmental Samples	Soil	131	22	132	11	73	73	74	24
	Sediment	45		42		23	25	17	10
	Groundwater	13		13		13	13	4	8
	Surface Water	14		14		12	13	13	11
	Seawater	4		4		4	4		
QA/QC Samples	Trip	34	2			32			
	Ambient	12				12			
	Equipment	11	2	11	NA	10	9	5	5
	Duplicate								
	•Soil/Sediment	13		13		8	8	6	1
	•Water	4		4		4	4	1	3

[a] NA indicates no analysis for indicated method(s) were performed.

[b] Site SS17 included in the Characterization of Site SS16.

range organics analyses provided the most appropriate and quantifiable method for determining the magnitude and extent of petroleum hydrocarbon contamination at the facility.

Gasoline Range Organics (Method AK101)--Historical uses and releases of gasoline at Kotzebue LRRS were not documented. To assess potential contamination resulting from gasoline use and spills, gasoline range organics (GROs) analyses were conducted at garage locations (AOC4-Power Plant/Garage and AOC8-White Alice Garage) where vehicle storage and maintenance occurred in the past. GROs analyses were also conducted on a site-specific basis if potential gasoline sources were identified or suspected (AOC3-East Tanks, AOC11-Truck Fueling Pad).

Volatile Organic Compounds (U.S. EPA Method 8260)--U.S. EPA Method 8260 was selected to characterize volatile organic contaminants associated with petroleum hydrocarbon contamination, and to evaluate other potential contaminant sources (e.g., waste oils and solvents).

Semivolatile Organic Compounds (U.S. EPA Method 8270)--Previous IRP investigations at Kotzebue LRRS had conducted only limited semivolatile organic compounds analyses. Approximately 10 percent (by weight) of middle-distillate fuels (diesel and jet fuels), which are the primary source of petroleum hydrocarbon contamination at Kotzebue LRRS, consist of semivolatile polynuclear aromatic hydrocarbons. In addition, waste oils and solvents stored and used at the installation may contribute semivolatile compounds at some sites. Method 8270 was used to characterize semivolatile compounds potentially present at Kotzebue LRRS.

Organochlorine Pesticides and PCBs (U.S. EPA Method 8081)--Pesticide use has not been documented at Kotzebue LRRS; however, pesticides may have been used to control insects in the vicinity of the installation. Previous investigations had detected relatively low concentrations of organochlorine pesticides, including 4,4'-DDT, at a number of sites. Therefore, Method 8081 was used to analyze samples for these chemicals during the 1994 RI. Method 8081 also measures PCBs, which had been detected in soils at the White Alice site and in a sediment sample collected from the former water supply lake during previous IRP investigations. PCB analyses conducted during the 1994 RI included samples of sediments in the former water supply lake (Site SS07), and samples of soils at locations not previously characterized where waste oils might have been present (see Table 4-5).

Metals (U.S. EPA 6000, 7000 Series)--Previous IRP investigations analyzed metals at a limited number of sites, including in soils at the SD03-Road Oiling and SS01-Waste Accumulation Area No. 1 sites, and in surface water at Site SS07-Lake. Metal concentrations in Kotzebue soils were reported to be within the range expected for native soil background concentrations. However, previous investigations did not sample background locations near Kotzebue LRRS for metals analysis to verify this assertion. Since literature values of typical concentrations are not a generally accepted substitute for site-specific background concentrations (*IRP Handbook*), metals analyses were conducted for selected sites based on the past use of waste oils spent solvents at select locations (see Table 4-5).

4.3.1.2 Natural Biodegradation Assessment. Water samples were analyzed for a suite of chemical parameters at two sites at Kotzebue LRRS: groundwater at the ST05-Beach Tanks site, and surface water at the SS12-Spills No. 2 and 3. Sampling at both sites included collection of three samples upgradient and downgradient along a flow path, with both proximal and distal downgradient samples collected and analyzed. At ST05-Beach Tanks, groundwater monitoring wells were also used to evaluate geochemical and contaminant trends in the near-beach aquifer.

Table 4-6 lists the analyses conducted to evaluate natural biodegradation at Kotzebue LRRS. The analyte list was adapted from a draft technical protocol developed by AFCEE for the evaluation of natural biodegradation at sites contaminated with petroleum hydrocarbons (Wiedemeier et al. 1994).

4.3.1.3 Fate and Transport Assessment. Three primary lithologies characterize the Kotzebue LRRS: beach sands and gravels; native soils associated with the tundra hill and surrounding area; and fill material used for roads and facility foundations. To support the contaminant migration assessment for each lithology, three geotechnical samples were collected from each lithology to evaluate physical properties, including permeability and grain size distribution. In addition to geotechnical information, three soil samples from each lithology were collected for the analysis of total organic carbon (TOC) to evaluate the potential for contaminant sorption within specific lithologies. The following tests were conducted for geotechnical and TOC characterization:

TABLE 4-6. FIELD SAMPLING AND ANALYSES SUMMARY FOR GEOCHEMICAL PARAMETERS FOR 1994 REMEDIAL INVESTIGATION KOTZEBUE LRRS, ALASKA

Analyses	Site Designation			
	ST05-Beach Tanks	SS12-Spills No. 2 and 3	Background	SS02-Waste Accumulation Area No. 2/Landfill
Media	Groundwater	Surface Water	Surface Water	Groundwater
Alkalinity (Field Test)	8	3	1	1
Ammonia (Field Test)	8	3	1	1
Chloride (Field Test)	8	3	1	1
Carbon Dioxide (Field Test)	8	3	1	1
Nitrate (Field Test)	8	3	1	1
Phosphate (Field Test)	8	3	1	1
Sulfate (Field Test)	8	3	1	1
Sulfide (Field Test)	8	3	1	1
Total Metals Fe/Na/Ca/K/Mg (EPA Method 6010)	8	3	1	3
Total Organic Carbon (EPA Method 9060)	8	3	1	1
pH (Field Measurement)	9	3	1	3
Temperature (Field Measurement)	9	3	1	3
Specific Conductivity (Field Measurement)	9	3	1	3
Dissolved Oxygen (Field Measurement)	8	3	1	1

Test	Test Method	Number of Samples		
		Beach Sands/ Gravels	Tundra	Fill
Soil Permeability	Constant-head (ASTM Method D5084)	3	3	3
Grain Size Distribution	ASTM C136 and D422	3	3	3
Total Organic Carbon (soil)	U.S. EPA Method 9060	3	3	3

4.3.2 QA/QC Program

The QAPP prepared for Kotzebue LRRS describes QA and QC procedures used to accomplish the RI/FS (USAF 1994c). This document includes the QA/QC procedures used for analytical work performed by the laboratory (Analytical Resources, Inc.), as well as the procedures used for the collection and management of data generated during the RI/FS process at Kotzebue LRRS. Key aspects of the QA/QC Program for Kotzebue LRRS are summarized below.

4.3.2.1 Field Quality Assurance/Quality Control. The field QA/QC program for Kotzebue LRRS included QC procedures associated with sample collection; periodic audits of field activities of Tetra Tech personnel and subcontractors; and corrective action measures designed to identify and resolve any deviations or noncompliance with contract specifications, approved procedures, the *IRP Handbook*, or the QAPP. A detailed discussion regarding field QA/QC activities is provided in the QAPP (USAF 1994c).

Field Activities Quality Control--QC procedures used during sample collection at Kotzebue LRRS are summarized below:

- A trip blank was shipped with every container of environmental samples sent to the analytical laboratory for analysis of volatile organic compounds.

- A temperature blank was shipped with every container of soil and water samples sent to the laboratory for chemical analysis.

- An ambient condition blank (prepared by pouring Reagent Grade Type II water into sample containers at the sampling site) was collected for every 10 volatile organic compound samples collected, or one per VOC sampling event.

- An equipment blank was collected daily from each piece of sampling equipment used to collect 10 or more field samples. If less than 10 samples were collected within a day, equipment blanks were collected based on a running cumulative total, at a 10 percent frequency.

- A duplicate water sample was collected at a frequency of 10 percent to measure sampling and analytical variability. The duplicate samples consisted of two samples collected independently at one sampling location during one act of sampling.

- A replicate soil samples was collected at a frequency of 10 percent to measure sampling and analytical variability. Replicates consisted of two sequential containers with soil from the same field sample.

- Chain-of-Custody forms accompanied all samples.

- Sampling equipment was thoroughly cleaned between each sampling event to prevent cross-contamination of the environmental samples.

Field Audits--Periodic audits of field activities of both field personnel and subcontractors was performed by the QA Field Auditor. The QA audits were conducted as soon as possible after initiation of each phase of project sampling (e.g., groundwater sampling event). The objectives of the field QA audit are listed below:

- Observe procedures and techniques used during field sampling and analysis
- Check and verify instrument and sampling equipment calibration records
- Assess the effectiveness of and adherence to prescribed QA procedures
- Review document control and Chain-of-Custody procedures
- Review the completeness of data forms and notebooks
- Review any nonconformance reporting procedures
- Identify any weaknesses in the sampling and analytical approach or techniques
- Assess the overall data quality of the various sampling/analytical systems employed at the time of the audit.

A report summarizing the field QA audit results is provided in Appendix G.

Corrective Actions--During the field effort at Kotzebue LRRS, the Project Manager and sampling team members were responsible for ensuring that all specified procedures were followed and that measurement data met the prescribed acceptance criteria. Deviations or noncompliance with contract specifications, approved procedures, the *IRP Handbook*, or the QAPP were considered points of nonconformance that could require specific corrective actions. Corrective action procedures for field activities are described in the QAPP (USAF 1994c). Based on the field audit results, no corrective actions were required and no specific points of nonconformance were identified for the 1994 field investigation (Appendix K).

4.3.2.2 Laboratory Quality Assurance/Quality Control.

Laboratory Audits--The Project QA/QC Manager and QA Auditor conducted an audit at Analytical Resources, Inc., within the first two weeks of the laboratory's receipt of project samples to verify that the QAPP, as well as the appropriate sections of the *IRP Handbook,* were being adhered to. All relevant components of the QAPP and the *IRP Handbook,* and their application to the laboratory's

analysis of environmental samples collected during the RI were reviewed. A report addressing the audit results and qualitative assessment of the overall system performance is provided in Appendix H. A final quality assurance report addressing all aspects of the QA/QC program implemented at Kotzebue LRRS is provided in Appendix K.

QA Auditors performed a five percent raw data audit onsite at the laboratory after all project samples had been submitted to the laboratory. During that data audit, the raw data, such as chromatograms and calculations, were compared to previously submitted final data packages for consistency and accuracy. During the raw data audit, manual integration of quality control and other samples were reviewed, and the operation of the instrument specific internal clocks was verified. Results of the five percent raw data audit are provided in Appendix I. Ten percent of the final analytical data generated during the RI field effort at Kotzebue LRRS were submitted to a third-party validator. Third-party validation offers an impartial assessment of previously reviewed/validated data. Results of the third-party data review are reported in the Analytical Data ITIR (USAF 1995c).

The final quality assurance report for the RI at Kotzebue LRRS, which contains an analysis of the QA/QC used to assess the quality of data generated during both field and laboratory operations, is provided in Appendix K.

Performance Evaluation Check Samples--Analytical Resources, Inc., participates in the following performance evaluation (PE) sample programs:

- U.S. EPA Semiannual Drinking Water Performance Check Samples (WS Samples)
- U.S. EPA Semiannual Wastewater Performance Check Samples (WP Series)
- U.S. EPA Contract Laboratory Program (CLP) quarterly blind sample program for organic analysis
- Analytical Products Group P.E.T. blind sample program

- U.S. Department of Energy Quality Assessment Program for Radiochemistry

- U.S. EPA NRA-RADQA Performance Evaluations for Radiochemistry.

Commercially available PE samples were forwarded to the laboratory as part of a blind sample auditing program. This program provides an external auditing function via PE samples to assess the analytical performance of laboratories under contract for non-CLP statements of work. The PE samples were sent to the laboratory from Kotzebue, Alaska, and were submitted as actual environmental field samples to avoid laboratory detection. Performance evaluation sample results are discussed in the five percent raw data audit report provided in Appendix I.

4.3.3 Data Reduction, Validation, and Reporting

Data reduction, validation, and reporting is the process by which analytical data are generated by the laboratory and subsequently reviewed using specified protocols so that the data may be used appropriately.

4.3.3.1 Data Reduction. Data reduction calculations used on data generated during sample collection at Kotzebue LRRS are provided in Analytical Resources SOP (USAF 1994b). All data generated had units consistent with those specified in the *IRP Handbook*. Data storage and documentation was maintained using logbooks and data sheets that were kept on file at the laboratory. All computer-generated raw data were stored on magnetic tape or other media, and will be maintained by the laboratory, along with paper copies, for one year after completion of all analytical tasks.

4.3.3.2 Data Validation. The analytical data review processes conducted by the laboratory during the RI field effort at Kotzebue LRRS are detailed in Table 4-7. Validation of data generated by the laboratory was the responsibility of the Project QA/QC Manager and Data Management Manager. The analytical data that resulted from environmental samples collected during the work effort at Kotzebue LRRS, were reviewed against the relevant criteria specified in original Statement of Work referred to as Level I criteria, as well as those provided in Contractor's QA's SOP entitled "*Preliminary Draft SOP for Quality Assurance Monitoring of Data Deliverables*" (effective date 26 January, 1995). An SOP entitled "*Data Qualification Guidelines for Inorganic & Organic Data Review Level I*" (effective date 7 March, 1994) was used to evaluate the data by the Data Management Group. After reviewing the SDG against

TABLE 4-7. LABORATORY ANALYTICAL DATA REVIEW PROCESS, 1994 REMEDIAL INVESTIGATION, KOTZEBUE LRRS, ALASKA	
	Responsibilities
Analyst	• Sample analysis and raw data generation • Data review - 1st level (bench) • Control charting/verification of acceptable QC results • Analytical notes • Data entry into LIMS • Discrepancy initiation and documentation of corrective actions • Provide copies of log books, as necessary
Supervisor	• Oversee daily analytical activities
Section Manager	• Ensure program compliance • Review discrepancies requiring manager resolution • Technical conference calls with client
Data Reporting and Review	• Generate data reports • Generate forms package • Final data review and validate • Electronic deliverables generation • Data validation • Review of analyst notes and corrective action reports • Supervise contractual and technical compliance • Discrepancy review • Review quality control daily (calibrations, etc.) • Ensure technical validity of data
Quality Assurance	• 10 percent contractual compliance review (data packages) - Custody when required; - Calculations; - Methods criteria; - QC criteria; - Forms; and - Control charting. • QA auditing
Project Manager	• Review and summarize analyst notes/corrective actions • Review packages for completeness and quality • Cover letter/case narrative • Collate organic and inorganic packages • Client/laboratory liaison • Prepare package and paginate • Maintain data package files • Deliver package to client

Level I SOP criteria, the Data Management Group compiles the necessary qualifiers and descriptors in tandem with input into the Informal Technical Information Report (ITIR).

Quality Assurance reviews the data verification/validation effort at two levels:

1. The qualifiers and descriptors applied to the sample results found in the ITIR; and
2. The qualifiers and descriptors found in the copy of the Sample Delivery group (SDG) laboratory deliverable.

Compliance with the Level I Verification SOP included a review of the following technical components:

- Analytical holding times
- Method and field blank results
- Matrix spikes/matrix spike duplicate results
- Laboratory control sample results
- Temperature blank results
- Duplicate environmental sample results
- The SDG supplied case narrative

The QA Auditor notes the discrepancy (if identified) in a memo to be forwarded to the Project Manager and Project QA/QC Manager with a copy to the Data Management Group Manager.

- Why the condition was evaluated as a discrepancy

- Where in the validation/verification portion of the ITIR the discrepancy was found

- Solutions for the discrepancies

Once the discrepancy memo was issued, QA set a date for incorporation of suggested edits followed by a request of documentation that indicated that the discrepancies had been resolved.

In addition to the USAF Level I data review, 10 percent of the project data packages from the laboratory were submitted in a USAF Level II [Contract Laboratory Program (CLP)-equivalent] format. The 10 percent USAF Level II data packages were reviewed and validated by a third-party validator. Results of the USAF Level II data review are reported in the Analytical Data ITIR (USAF 1995c).

4.3.3.3 ***Data Reporting.*** Data generated during the RI field effort at Kotzebue LRRS were incorporated into the IRPIMS database program. The most recent Contractor Data Loading Tool (CDLT) and QC Tool Program were used for the IRPIMS deliverable, in conjunction with Contractor's SOPs specified for this task.

All data gathered during the field effort at Kotzebue LRRS are reported in the appropriate ITIRs. The Analytical Data ITIR contains all relevant portions, as detailed in the *IRP Handbook*. In addition to *IRP Handbook* protocol, all data were reviewed using Contractor's SOPs specific to that task. The resulting reviewed and, if appropriate, qualified data, are provided in the Analytical Data ITIR (USAF 1995c).

4.4 FIELD INVESTIGATION ACTIVITIES

This section provides a summary of field activities conducted at 14 sites and 5 areas of concern during the 1994 RI at Kotzebue LRRS (see Figure 4-1 and Table 4-4). A detailed description of specific activities and field tasks can be found in the FSP (USAF 1994c).

4.4.1 Field Screening Techniques

Field screening included assessing organic vapors, TPH, and PCB.

4.4.1.1 Screening for Organic Vapors. During site reconnaissance, a photoionization detector (PID) was used to locate elevated concentrations of ionizable organic vapors. Elevated readings identified specific areas for potential sampling. During sampling activities, a PID was also used to screen samples and prioritize those selected for laboratory analysis.

4.4.1.2 Screening for TPH and PCB. Field screening for the presence of TPH and PCBs was performed on a limited number of soil samples using field test kits. TPH screening was performed using

a commercially available petroleum hydrocarbon test kit (color indicator). PCB screening was performed using Dexsil CLOR-N-SOIL® field test kits.

4.4.2 Environmental Sampling Methods

Environmental samples collected by the field investigation team included surface and subsurface soil, geotechnical, sediment, surface water, groundwater, and seawater samples. Detailed descriptions of sample collection procedures are provided in the FSP (USAF 1994c).

4.4.2.1 Surface and Shallow Subsoil Sampling. Soil samples were selected for analysis either from zones of obvious contamination identified by field screening procedures, the base of gravel fill material, the tundra mat/silt interface, or the top of the permafrost. Surface (0 to 1.0 ft) and shallow subsoil samples (1.0 to 6.0 ft below ground surface) were collected using a clean, stainless steel 3-in internal diameter (i.d.) hand-auger.

4.4.2.2 Subsoil Sampling. Borings for subsoil sampling were advanced using a mobile track-mounted drill rig equipped with 4.25-inch i.d. hollow-stem augers. Borings were advanced using standard drill-and-drive techniques. Standard penetration test data were recorded for each sample drive in blows per 6 inches. A registered geologist supervised the drilling and prepared lithologic logs of borings using the Unified Soil Classification System (USCS). Undisturbed subsoil samples were collected using the Standard Penetration Test procedure split-spoon method. Sample material was selected for laboratory analysis from zones of obvious contamination and based on field screening information.

4.4.2.3 Geotechnical Sampling. Geotechnical sampling included bulk soil samples collected in 1-gallon plastic containers for grain-size analysis. Undisturbed soil samples for permeability testing were collected using Shelby tubes.

4.4.2.4 Lake Sediment Sampling. Relatively undisturbed lake sediment samples were collected from near-shore locations using a clean stainless-steel 3-in. i.d. hand auger.

4.4.2.5 Surface Water Sampling. Surface water samples were collected from lakes, standing water locations at Sites SS12, SS11, AOC1, and AOC6, and from Kotzebue Sound. Extreme care was taken not to suspend sediment in the water prior to or during sampling. Surface water samples were collected prior

to collecting sediment samples at all lake locations. A Wheaton surface water sampler was used to collect representative water samples from below the water surface.

4.4.2.6 Groundwater Sampling. Groundwater samples were collected from newly installed near-beach monitoring wells. Monitoring wells were developed and stabilized prior to sample collection. Groundwater was purged from each monitoring well prior to sample collection using a clean stainless steel bailer. Groundwater sampling was conducted in all monitoring wells using a Teflon bailer with a dedicated bailer line [and a Teflon bottom-emptying device for volatile organic compounds (VOC) samples only].

4.4.2.7 Seawater Sampling. The collection of seawater samples was conducted using surface water sample collection procedures. Seawater samples were collected from below the water surface, approximately 5 ft from the high tide mark.

4.4.3 Decontamination Procedures

All equipment that came in contact with potentially contaminated soil, sediment, or water was decontaminated after each use and between each sample location. Equipment decontamination procedures were developed for equipment employed during the field investigation, including specific procedures for large equipment (e.g., drill rig, auger flights, and well casing), small tools and sampling devices (e.g., split-spoons, bailers, hand-augers), and field instruments (e.g., tapes, well sounders, transducers, and water quality probes). Detailed decontamination procedures are outlined in the FSP (USAF 1994c).

4.4.4 Monitoring Well Installation and Development

A total of 13 groundwater monitoring wells were installed at Kotzebue LRRS between 27 June and 11 July 1994, to facilitate an evaluation of near-beach groundwater quality and potentiometric levels (Figure 4-2). Three shallow groundwater monitoring wells were installed in assumed downgradient locations between Site SS02-Waste Accumulation Area No. 2/Landfill and Kotzebue Sound to evaluate potential contaminant migration via groundwater. Shallow groundwater monitoring wells were installed in nine of the 24 boreholes advanced at the ST05-Beach Tanks Site to estimate the extent of groundwater contamination, provide representative and reproducible groundwater samples for aquifer characterization, and to evaluate the groundwater potentiometric surface (see Figure 4-2). Six additional deeper wells were to be installed to evaluate the physical and chemical characteristics of the aquifer at depth for Site ST05. However, frozen ground encountered at relatively shallow depths in the forebeach well locations, and the

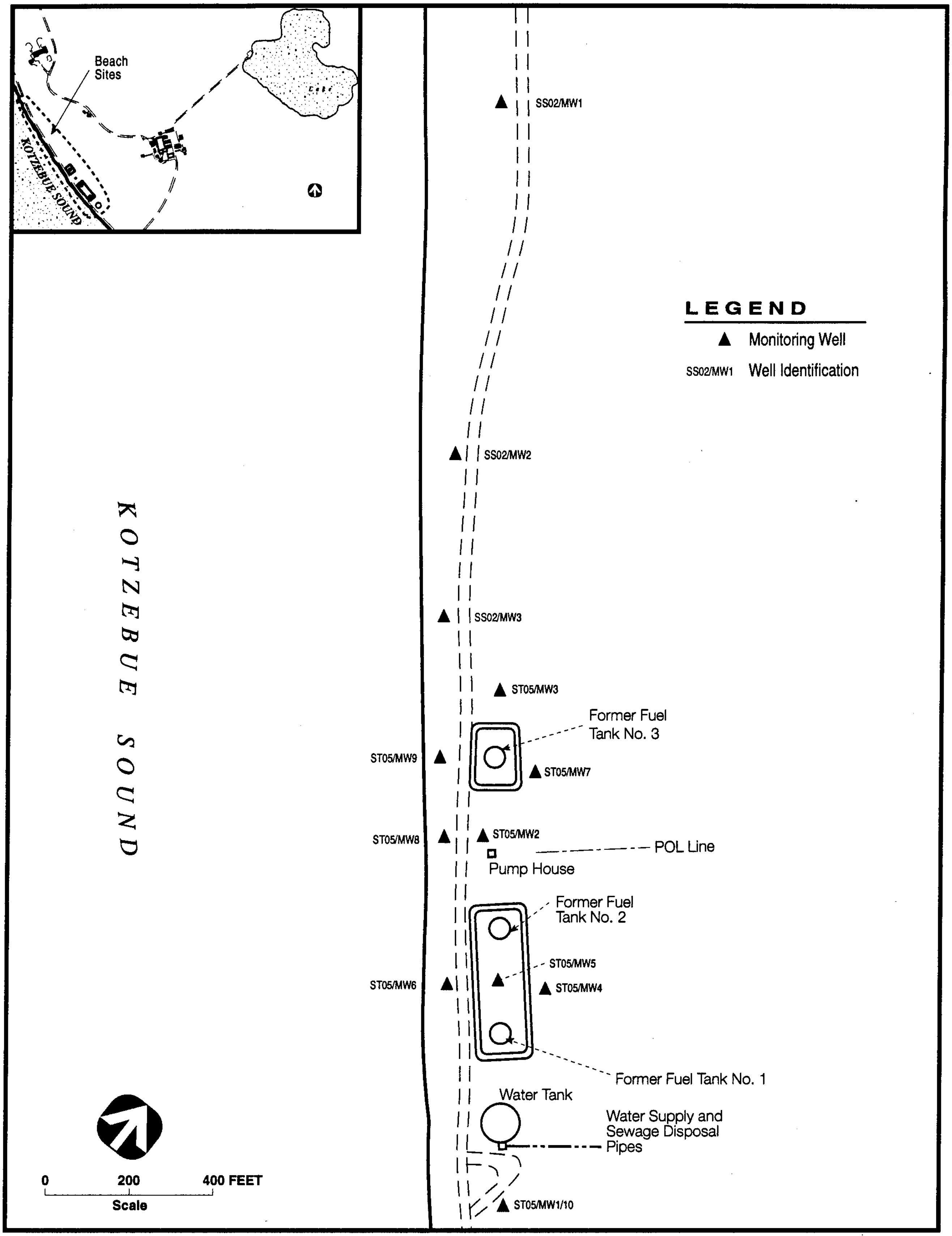

Figure 4-2. Monitoring Wells Installed During 1994 Remedial Investigation at Kotzebue LRRS, Alaska.

presence of a sandy silt/silty clay confining layer at approximately 13 feet below ground surface pre-empted the installation of the deeper wells. One groundwater monitoring well was installed north of Site SS02 to characterize background groundwater quality (see Section 4.4.10, Background Characterization).

4.4.4.1 Monitoring Well Installation. A USAF drilling permit was obtained prior to the commencement of drilling at Kotzebue LRRS. The drilling permit was signed by a USAF Site Operator and copies kept at the site during drilling. The utilities at Kotzebue LRRS are located above ground, because of the presence of permafrost. All well construction materials such as well casings, screens, sand, and bentonite were provided by the drilling contractor. Well screens and casing were delivered to the site clean, wrapped in plastic, and boxed. Casing and screen sections were kept covered until they were assembled and lowered into the borehole. Figure 4-3 provides a construction diagram for a typical groundwater monitoring well installed at Kotzebue LRRS.

The borings in which monitoring wells were installed were drilled using a track-mounted hollow-stem auger drill rig equipped with 4.25-inch inside diameter (i.d.) hollow-stem augers. Borings were advanced using standard drill-and-drive techniques. Standard penetration test data were recorded for each sample drive in blows per 6 inches. A registered geologist supervised all drilling and well installations, and prepared lithologic logs of borings using the Unified Soil Classification System (USCS). Table 4-8 provides groundwater monitoring well construction information. Boring logs for wells installed at Kotzebue LRRS are provided in Appendix A, and well completion diagrams are provided in Appendix B.

Screen and Casing Construction and Placement--Monitoring wells were constructed using 2-inch i.d. Schedule 40 pvc casing and screen. Well screens typically consist of 0.02-inch slot size. However, 0.01-inch screen slot size was used for the construction of wells completed in finer-grained material (see Table 4-8). All monitoring well screen intervals were approximately 5 feet in length (see Appendix B).

Groundwater monitoring well screen intervals were chosen to encompass seasonal variations in the elevation of the groundwater surface. However, this was difficult to accomplish in monitoring wells installed along the forebeach at Kotzebue LRRS due to the shallow nature of groundwater and the required construction of a surface seal at a minimum of 2 feet above the filter pack (see Appendix B).

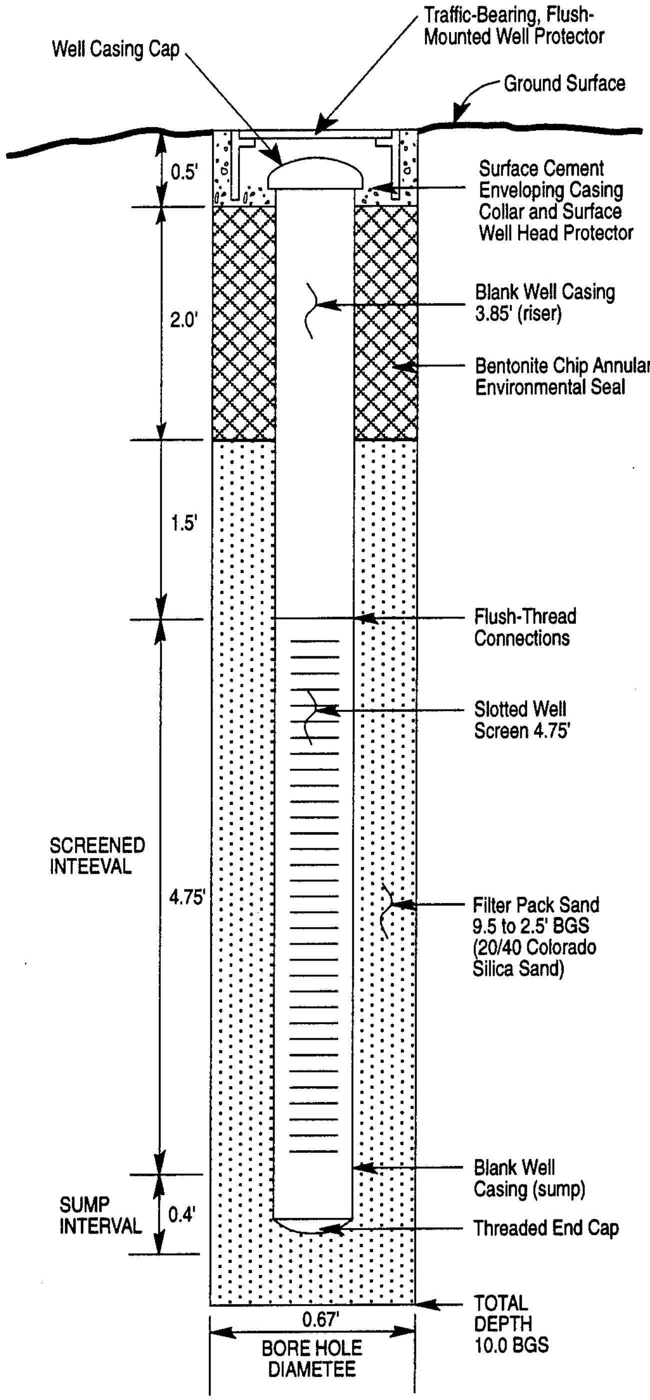

Figure 4-3. Construction Diagram for Typical Groundwater Monitoring Well Installed During 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

TABLE 4-8. SUMMARY OF GROUNDWATER MONITORING WELL CONSTRUCTION INFORMATION, 1994 REMEDIAL INVESTIGATION, KOTZEBUE LRRS, ALASKA

Well Identification	Date Installed	Total Depth (ft)	Screen Interval (ft)	Sanitary Seal Interval (ft)	Casing Diameter (in)	Slot Size (in)	Sand Pack	TOC Elevation (ft)	Ground Sur. Elevation (ft)	Surface Completion
Background-MW1	6-27-94	10.75	5.6 to 10.4	1.0 to 5.0	2	0.02	10/20	8.13	8.79	Flush Mount
SS02-MW1	6-30-94	11.10	6.0 to 10.7	1.0 to 4.5	2	0.02	10/20	8.07	8.59	Flush Mount
SS02-MW2	7-08-94	9.00	3.9 to 8.6	0.5 to 2.5	2	0.01	20/40	5.13	5.59	Flush Mount
SS02-MW3	6-30-94	9.00	3.9 to 8.6	1.0 to 3.0	2	0.02	10/20	4.39	4.81	Flush Mount
ST05-MW1	6-28-94	12.00	6.9 to 11.6	1.0 to 5.5	2	0.02	10/20	9.21	9.75	Flush Mount
ST05-MW2	6-28-94	12.10	6.9 to 11.7	1.0 to 5.5	2	0.02	10/20	9.13	9.78	Flush Mount
ST05-MW3	6-29-94	9.90	4.8 to 9.5	1.0 to 4.0	2	0.02	10/20	8.68	9.22	Flush Mount
ST05-MW4	7-07-94	11.00	5.9 to 10.6	1.0 to 4.75	2	0.02	10/20	8.26	8.59	Flush Mount
ST05-MW5	7-09-94	9.00	3.9 to 8.6	0.5 to 3.0	2	0.02	10/20	6.60	7.21	Flush Mount
ST05-MW6	7-09-94	9.50	4.4 to 9.1	0.5 to 3.0	2	0.01	20/40	5.02	5.66	Flush Mount
ST05-MW7	7-10-94	9.15	4.0 to 8.8	0.5 to 3.0	2	0.02	10/20	6.61	7.01	Flush Mount
ST05-MW8	7-10-94	9.15	4.0 to 8.8	0.5 to 3.0	2	0.01	20/40	5.03	5.61	Flush Mount
ST05-MW9	7-11-94	9.15	4.0 to 8.8	0.5 to 3.0	2	0.02	10/20	5.70	6.20	Flush Mount

Filter Pack Placement--All monitoring wells included an artificial filter pack consisting of 10-20 silica sand for 0.02 inch slot screened wells and 20-40 silica sand for 0.01 inch slot screened wells (see Table 4-8).

Filter pack material was carefully added to the borehole annulus to avoid bridging of the filter pack material between the casing and the hollow stem of the auger. The volume of filter pack material required was calculated to detect possible sand bridging or slumping of the borehole wall against the screened interval. Each well was surged several times to settle the filter pack. The filter pack extended a minimum of 6 inches above the top of the screened interval (i.e., forebeach monitoring well locations). The filter pack was extended further above the screen at locations where the depth to groundwater permitted compliance with the *IRP Handbook*.

Bentonite Seal Placement and Well Head Completion--Following placement of the filter pack, sodium bentonite chips were added to within 1 feet of the ground surface and hydrated to form a seal above the filter pack. Each bentonite seal was completed with a minimum thickness of 2.0 feet.

Well heads were completed at grade using a flush mount aluminum well cover set in a concrete surface seal. The well identification was permanently marked on the well cap and on the locking monument.

Surveying--Monitoring wells were surveyed according to specifications presented in Section 4.4.11, Sample Location Survey.

4.4.4.2 Monitoring Well Development. Monitoring well development was conducted between 05 July and 14 July 1994 at Kotzebue LRRS. Each newly installed monitoring well was developed no sooner than 24 hours and no later than 5 days after completion. Well development was conducted using a combination of bailing and surging. No water was added to the well during development. Table 4-9 provides monitoring well development information for Kotzebue LRRS.

4.4.4.3 Groundwater Purging. All groundwater monitoring wells were purged immediately prior to groundwater sample collection. A minimum of three to five casing volumes were removed from each well using a clean stainless steel bailer and dedicated bailer line. Field parameters including pH, conductivity, temperature, and turbidity were measured during well purging to monitor water quality parameter

TABLE 4-9. SUMMARY OF MONITORING WELL DEVELOPMENT INFORMATION, 1994 REMEDIAL INVESTIGATION, KOTZEBUE LRRS, ALASKA

Well Identification	Date Developed	Calculated Casing Vol. (gal)	Total Purge Volume (gal)	Initial Readings					Final Readings						Purge Induced Drawdown (ft)[b]
				Temp (° C)	pH	Cond. (μmhos/cm)	Turbidity (NTU)	Brief Description	Temp (° C)	pH	Cond. (μmhos/cm)	Turbidity (NTU)	Brief Description	Imhoff (mL)	
Background MW1	7-06-94	0.6	63	6.5	6.1	227	>100	Brown-gray, very turbid	6.0	5.7	250	15	Straw yellow-brown, slight turbidity	0.2 at 55 gal	0.04
SS02-MW1	7-06-94	0.8	59	4.0	5.1	353	>100	Brown, very turbid	2.8	5.5	259	61	Straw gray, minor organics	2.0 at 45 gal	0.03
SS02-MW2	7-14-94	0.7	25	4.5	7.8	360	>100	Turbid, no odor, no sheen	5.0	7.8	330	48	Low turbidity, no odor, no sheen	--	Purged dry at 2 gal
SS02-MW3	7-06-94	1.0	56	5.0	5.9	360	>100	Petroleum odor, slight sheen	4.3	5.9	340	65	Tan, slight to moderate turbidity	0.6 at 40 gal	0.07
ST05-MW1	7-08-94	0.7	55	4.5	7.3	240	>100	Brown, turbid, no odor, no sheen	4.0	7.4	240	--[a]	Light brown, slight to moderate turbidity	--	Produces readily
ST05-MW2	7-08-94	0.6	53	3.5	6.9	443	>100	Petroleum odor, slight sheen	3.0	6.9	413	90[a]	Petroleum odor, slight sheen, turbid	--	-0.67
ST05-MW3	7-08-94	0.5	48	4.0	7.3	315	>100	Brown, very turbid, no odor	4.0	7.3	300	--[a]	Light amber, petroleum odor, slightly turbid	--	Produces readily
ST05-MW4	7-08-94	0.7	110	4.0	7.2	200	>100	Dark brown, very turbid, no odor	5.0	7.8	195	--[a]	Transparent, very slight turbidity	11 at 40 gal	Produces readily
ST05-MW5	7-11-94	0.7	55	5.2	7.0	325	>100	Brown, turbid, petroleum odor, sheen	4.0	7.0	280	40	Slightly turbid, petroleum odor, sheen	--	-0.03
ST05-MW6	7-11-94	0.9	55	3.5	6.8	375	>100	Brown, turbid, petroleum odor, sheen	4.0	6.9	370	60	Slightly turbid, petroleum odor, sheen	--	-0.38
ST05-MW7	7-13-94	0.7	55	6.0	6.8	310	>100	Turbid, no odor, no sheen	3.7	6.9	238	85	Slightly turbid, no odor, no sheen	--	0.02
ST05-MW8	7-13-94	0.7	20	4.8	6.7	500	>100	Turbid, petroleum odor, sheen	5.7	6.7	480	>100	Turbid, petroleum odor, sheen	--	Purged dry at 5 gal
ST05-MW9	7-12-94	0.7	30	4.0	6.8	395	>100	Turbid, petroleum odor, sheen	3.5	6.8	420	--	Water clear, petroleum odor, sheen	--	0.02

[a] Turbidity meter not reliable due to excessive moisture from rain.

[b] Minus values indicate a rise in groundwater level produced by bailing/tidal influence?

stability prior to sample collection. Table 4-10 provides monitoring well purge information for Kotzebue LRRS.

Wastewater generated during monitoring well installation was containerized in 55-gallon drums, properly labeled, and stored onsite (see Section 4.4.12, Investigation Derived Waste Management).

4.4.5 Aquifer Characterization

Near-beach aquifer parameters, including horizontal hydraulic gradients, groundwater flow rate and direction, and hydraulic conductivity were measured during the Kotzebue LRRS 1994 RI. Hydraulic gradients and groundwater flow direction were determined using water level measurements in monitoring wells. Hydraulic conductivity was estimated by conducting falling and rising head slug tests in selected monitoring wells. Groundwater flow rates were established based on hydraulic gradient measurements and hydraulic conductivity estimates.

Tidal monitoring was conducted in monitoring wells installed at the ST05-Beach Tanks Site to determine the magnitude and extent of tidal influences on the local near-beach groundwater system. Tidal monitoring activities are discussed in detail in Section 4.4.6, Tidal Influence Assessment.

4.4.5.1 Static Water Level Measurement. Three independent series of static water level measurements were collected during the 1994 field investigation. Water level measurements were conducted using an electronic water level indicator to measure the depth to the groundwater surface in each monitoring well installed at Kotzebue LRRS (see Figure 4-2). All water level measurements were taken from the same location in each monitoring well, identified by a permanent notch placed in the top of the well casing. The measuring tape and probe were decontaminated between each groundwater measurement. Static water level measurement results are discussed in Section 4.6.1, Static Water Level Measurements.

4.4.5.2 Aquifer Slug Tests. Slug tests were conducted in three monitoring wells (ST05-MW4, MW5, MW6) installed in the vicinity of the ST05-Beach Tanks Site to evaluate horizontal hydraulic conductivity in the near-beach aquifer at Kotzebue LRRS (see Figure 4-2). The slug tests consisted of both rising-head and falling-head tests performed using a slug designed for 2-inch i.d. monitoring well construction. All downwell aquifer testing equipment was decontaminated prior to initial use and between well locations.

TABLE 4-10. SUMMARY OF GROUNDWATER PURGE INFORMATION, 1994 REMEDIAL INVESTIGATION, KOTZEBUE LRRS, ALASKA

Well Identification	Date Sampled	Casing Volume (gal)	Gallons Purged	Field Parameter Measurement				Sample Description
				pH	Conductivity (μmhos/cm)	Temperature (^oC)	Turbidity (NTU)	
ST05-MW1	7/17/94	0.83	4.0	6.80	220	3.0	20	Light straw yellow, no odor or sheen, low turbidity
ST05-MW2	7/17/94	0.78	4.0	7.25	550	3.0	30	Straw yellow, slight odor with trace sheen, suspended organics
ST05-MW3	7/18/94	0.46	3.0	6.93	280	3.0	15	Pale straw yellow, no odor or sheen, slight turbidity
ST05-MW4	7/17/94	0.70	4.0	7.09	220	4.0	60	Light grayish brown, no odor or sheen, moderate turbidity
ST05-MW5	7/17/94	0.66	5.0	6.23	320	3.0	45	Dark amber, no odor, very slight sheen observed
ST05-MW6	7/17/94	0.89	4.0	6.50	2,100	3.0	30	Straw yellow, slight odor with slight sheen, low turbidity
ST05-MW7	7/18/94	0.72	3.0	6.64	330	3.5	33	Straw yellow, no odor or sheen, suspended organics
ST05-MW8	7/18/94	0.80	8.0	6.75	1,100	3.0	20	Straw yellow, slight odor with slight sheen, low turbidity
ST05-MW9	7/18/94	0.70	4.0	6.77	340	3.0	18	Straw yellow, slight odor, no visible sheen, slight turbidity
SS02-MW1	7/14/94	0.70	5.0	7.42	275	3.0	60	Light straw yellow, no odor or sheen, slight turbidity
SS02-MW2	7/18/94	0.74	4.0	7.73	320	3.0	9	Light amber, no odor or sheen, very slight turbidity
SS02-MW3	7/18/94	0.49	3.75	7.54	400	3.5	12	Pale straw, very slight odor and sheen observed
Background-MW1	7/14/94	0.54	5.0	6.98	560	3.0	15	Translucent, no odor or sheen

Calibrated pressure transducers were placed into the monitoring well and connected to a data logger system used to continuously record groundwater level fluctuations during testing. The data loggers were programmed for slug testing prior to field installation and activation. They were initially programmed for a sample frequency of five seconds for the duration of the slug test due to the relatively high hydraulic conductivities anticipated in the Kotzebue Sound Beach area. However, it was determined that hydraulic conductivities were even higher than anticipated (i.e., rapid water level recovery time) and the sample frequency was increased to 0.5 second intervals.

Static water level measurements collected prior to each slug test indicated a groundwater surface below the top of the well screen interval in two monitoring wells. The groundwater surface in wells ST05-MW4 and ST05-MW5 were 0.53 feet and 0.90 feet below the top of the screen, respectively. However, monitoring well ST05-MW6 indicated a groundwater level at 0.79 feet above the top of the well screen. In monitoring wells ST05-MW4 and MW5, where static water levels are within the screened interval, falling-head slug tests (slug injections) may produce an overestimated value of hydraulic conductivity due to preferential flow into the unsaturated zone from the exposed screen interval (Freeze and Cherry 1979). Therefore, hydraulic conductivity values have been estimated using the rising-head (slug extraction) portion of the slug test. Aquifer slug test results are discussed in Section 4.6.2, Slug Test Results.

4.4.6 Tidal Influence Assessment

The influences of tides on the Kotzebue LRRS near-beach groundwater system can directly affect hydraulic characteristics and geochemistry, thereby effecting contaminant migration and impacting the evaluation of potential remedial alternatives. Previous IRP site characterization studies indicate that the near-beach groundwater system at Kotzebue LRRS is influenced by tidal fluctuations in Kotzebue Sound. Water level measurements collected in wells installed during the Kotzebue LRRS 1994 remedial investigation show response in water levels relative to high and low tide cycles in Kotzebue Sound (see Section 4.6.1, Static Water Level Measurements.

Continuous tidal monitoring was conducted between 24 July and 26 July 1994 to evaluate diurnal tidal influences on the near-beach unconfined groundwater system at Kotzebue LRRS. Tidal monitoring was conducted during a period of high tidal fluctuation to increase the potential for measurable communication between the near-beach aquifer and Kotzebue Sound. Three shallow monitoring wells installed at Site ST05 were selected to evaluate tidal influence on the near-beach groundwater system. These wells

include ST05-MW4 (back-beach), ST05-MW5 (mid-beach), and ST05-MW6 (fore-beach) (see Figure 4-2). In addition to monitoring wells, a standpipe was to be installed at the shoreline to provide baseline tidal data for comparison with tide chart predictions and well response records. However, attempts to install the shoreline station (standpipe) failed due to a moderately steep beach face and unconsolidated beach sands and gravel which prevented the standpipe from remaining stationary and providing a common point of reference (top of standpipe) for tidal measurement.

A calibrated pressure transducer (15 psi) was placed in each monitoring well and connected to a Terra8, four-channel data logger system programmed to continuously record groundwater level fluctuations at a sample frequency of 10 minutes for the duration of the test. Tidal monitoring was conducted for a 48-hr period to encompass four diurnal tide cycles. During the installation of pressure transducers for tidal monitoring it was determined that two 10 psi transducer sensors were non-functional; assumed damaged during transport to the site. Only two functional 15 psi pressure transducers were now available to field personnel. A decision was made to place one transducer in the fore-beach monitoring well (MW6) for the duration of the test. The other transducer was placed in the back-beach well MW4 for the first 24 hours of the test, and then it was moved to the mid-beach well MW5 for the remaining 24 hours of the test. Tidal monitoring results are discussed in Section 4.6.3, Tidal Monitoring Results.

4.4.7 Geotechnical Assessment

Three primary lithologies characterize the Kotzebue LRRS. They consist of beach sands and gravels, native silty soils associated with the tundra hill and surrounding area, and gravel fill material used for roads and facility foundations. To support the contaminant migration assessment for each lithology, three geotechnical samples from each lithology were collected to evaluate their physical properties, including permeability and grain size distribution. In addition to geotechnical sampling, three soil samples from each lithology were collected for the analysis of total organic carbon (TOC) to evaluate the potential for contaminant sorption within specific lithologies. The following tests were conducted for geotechnical and TOC characterization:

Test	Test Method	Number of Samples		
		Beach Sands/ Gravels	Silty Soil	Gravel Fill
Soil Permeability	Constant-head (ASTM Method D5084)	3	3	3
Grain Size Distribution	ASTM C136 and D422	3	3	3
Total Organic Carbon (soil)	EPA Method 9060	3	3	3

Three soil samples were collected from the Kotzebue LRRS beach area, one each in the back-beach (Sample SS02-6710-B), mid-beach (Sample ST05-GT7-B), and fore-beach (Sample SS02-GT8-B) areas, and submitted for grain-size analysis, soil permeability testing, and total organic carbon. Samples were collected from the vadose zone above the groundwater surface and from the saturated zone just below the groundwater surface. Sampling was conducted in areas determined to be free of contamination by the field sampling team (Figure 4-4). Shelby tubes were to be used to collect undisturbed sediment samples from the beach area for permeability testing. However, due to the unconsolidated nature of these materials (including sandy Gravels) the shelby tubes were unable to collect an undisturbed sample. Beach area soils collected for permeability testing required recompaction by the testing laboratory.

Three geotechnical and TOC soil samples including AOC8-GT1-T, AOC6-GT3-T, and AOC7-GT6-T were collected to characterize the native tundra environment at Kotzebue LRRS (see Figure 4-4). Geotechnical sampling was conducted in areas assumed to be free of contamination. Geotechnical samples were submitted for grain-size analysis and soil permeability testing. Total organic carbon samples were collected at each location. Shelby tubes were used to collect undisturbed samples for permeability testing.

Three geotechnical and TOC soil samples were collected to characterize engineered fill materials at Kotzebue LRRS, including Samples AOC8-GT2-F, AOC6-GT4-F, and AOC4-GT5-F (see Figure 4-4). Geotechnical sampling was conducted in areas assumed to be free of contamination. Undisturbed soil samples were collected in Shelby tubes for permeability testing. Geotechnical samples were submitted

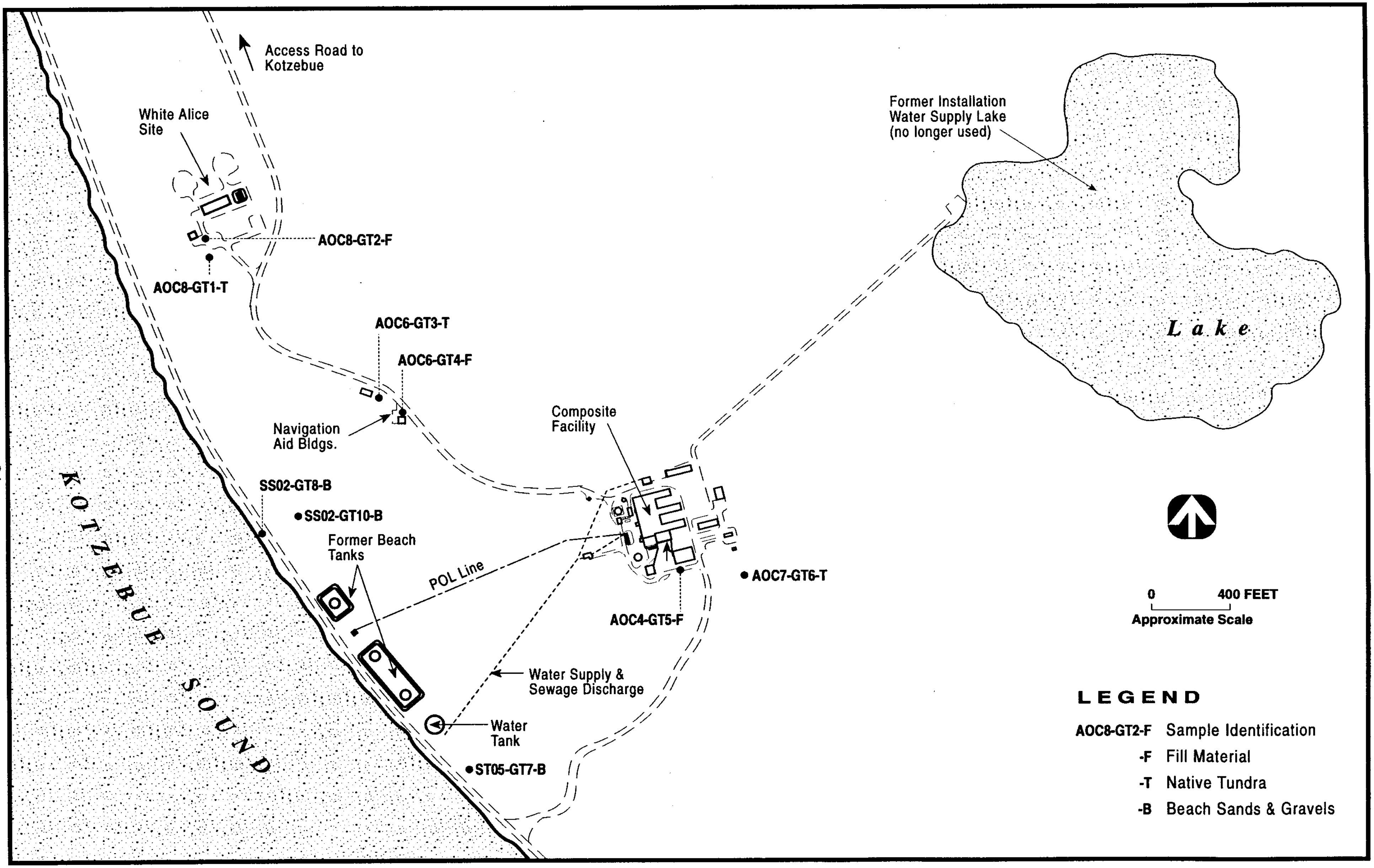

Figure 4-4. Geotechnical Sample Station Locations, 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

for grain-size analysis and soil permeability testing. Total organic carbon samples were collected at each location. Results of the geotechnical assessment conducted at Kotzebue LRRS are discussed in Section 4.6.4, Geotechnical Sample Results.

4.4.8 Gradiometric Survey

During a previous IRP investigation conducted at Kotzebue LRRS some former landfill wastes were reported buried within the SS02-Waste Accumulation Area No. 2/Landfill Site (see Figure 4-1). In September 1993, a site survey was conducted at Site SS02, revealing areas of mounding that contain landfill debris, including metal wastes such as drums and other empty containers and metal debris. The buried landfill wastes described during previous IRP investigation were suspected to comprise the mounding observed during the 1993 Site Survey.

During the Kotzebue LRRS 1994 RI, a gradiometric survey at Site SS02-Waste Accumulation Area No. 2/Landfill was conducted to identify the presence or absence of buried metallic objects and their locations. A Ferro-Trac™ magnetic locator (Model No. FT-60) was used to map the lateral extent of buried metallic debris. The hand-held locator contains two magnetic sensors. The two sensors are used to balance out the effect of the Earth's magnetic field. As the locator passes over the ground surface, it reacts to changes in the ambient magnetic field caused by the proximity of the lower sensor to buried metallic objects. These changes are displayed as an audio signal and on a meter built into the locator. Prior to conducting the gradiometric survey the locator was calibrated (zeroed) in an area where buried metallic objects were not anticipated to be present.

The gradiometric survey was conducted by establishing a grid oriented parallel to the long axis of the landfill and using 25-feet spacings between instrument readings. The grid consisted of 50 rows including seven cells of 25 by 25 feet grids in each row for a total of 350 cells. Results of the gradiometric survey are discussed in Section 4.6.5, Gradiometric Survey Results.

4.4.9 Natural Attenuation Assessment

Data has been obtained to specifically address whether natural attenuation is active, and to what extent biodegradation may be responsible for the reduction of petroleum hydrocarbon contaminant concentrations in soils, surface water, and groundwater at Kotzebue LRRS. Geochemical parameters were measured in surface waters and groundwater both upgradient and downgradient of known source areas to document

the relationship between aqueous geochemistry and contaminant chemistry, allowing an evaluation of the effect of natural biodegradation on these two impacted media at known source areas. Additionally, soils have been evaluated using carbon chain ratios (straight-chain/branched-chain) to determine the difference in composition between fresh and degraded diesel fuel at known source areas. Results of the natural attenuation assessment are provided in Section 4.6.6. The following sections discuss the methodology employed to assess natural attenuation of petroleum hydrocarbon contaminants in soils, surface waters, and groundwater at Kotzebue LRRS.

4.4.9.1 Soils. A method has been developed to evaluate whether natural attenuation is active, and to what extent biodegradation may be responsible for a lowering of arctic-grade diesel fuel contaminant concentrations at Kotzebue LRRS. Diesel fuel is a complex mixture of hydrocarbons produced by the distillation of crude oil. The dominant hydrocarbons in fresh diesel fuel are n-alkanes that range from C_9 to C_{20}. Analyses have shown that the dominant compounds found in environmentally degraded diesel fuel are branched-chain hydrocarbons called isoprenoids (Christensen and Larson 1993). Differences in the composition of fresh and degraded diesel fuel have been expressed in terms of a ratio between n-alkanes (straight-chain) and isoprenoids (branched-chain) hydrocarbons (e.g., C_{17}/pristane). Diesel fuel TPH analyses typically measure hydrocarbons in the range of C_9 to C_{20}. An evaluation of straight-chain/branched-chain ratios provides a method to demonstrate the occurrence of natural attenuation of diesel fuel contamination in soils at Kotzebue LRRS.

Previous studies citing the use of carbon ratios to evaluate diesel fuel degradation in soils have typically depended on the use of C_{17}/pristane, C_{18}/phytane, and pristane/phytane ratios for measuring biodegradation in soils (Glaser 1991; Flathman et al. 1991). Branched-chained hydrocarbons such as pristane and phytane, are more resistant to biodegradation than straight-chained C_{17} and C_{18}. As biodegradation proceeds, the ratios of straight-chain to branched-chain hydrocarbons will decrease (Christensen and Larson 1993). The primary source of TPH and BETX compounds detected in soils and waters at Kotzebue LRRS is arctic-grade diesel fuel, which contains more low molecular weight hydrocarbons than does normal diesel fuel. This fact is confirmed by a review of chromatograms generated from the analysis of product material (i.e., arctic-grade diesel fuel) and from analysis conducted on weathered soil samples collected from areas of known diesel-fuel release (e.g., Site SS12-Spills No. 2 and 3). Chromatograms of arctic-grade diesel and associated weathered soil samples reveal alkanes concentrated in the C_{12} to C_{13} range; typically showing very low alkane detection past C_{15} or C_{16}. Due

to the lighter nature of arctic diesel fuel the use of typical ratio pairs (C_{17}/pristane or C_{18}/phytane) to evaluate biodegradation in soils is not practical at Kotzebue LRRS.

A method has been developed through gas chromatography/mass spectrometry (GC/MS) analysis to evaluate straight-chain/branched-chain hydrocarbon ratios in arctic-grade diesel fuel and in weathered soil samples collected at Kotzebue LRRS. The following section discusses the methodology employed, site/sample selection criteria, and carbon ratio results used which suggest that natural attenuation is active, and that microbial biodegradation may be responsible for TPH concentration reduction at Kotzebue LRRS.

Study Approach--A sample of arctic-grade diesel fuel was collected from a fuel distribution source in Kotzebue, Alaska. The sample was submitted for GC/MS analysis. Results of the arctic-diesel standard revealed the predominance of the straight chain alkanes discussed by Christensen and Larson (1993). The analytical laboratory then performed GC/MS analysis on a selected a number of soil samples submitted from Kotzebue LRRS. When the arctic-grade diesel standard results were compared to those of weathered samples, a significant decrease in straight-chain hydrocarbons was observed between the diesel standard and the material extracted from the weathered soils. In addition, a number of branched-chain hydrocarbons were identified from the soils which appeared to be conservative when compared with similar branched-chain hydrocarbons identified in the original diesel fuel standard. Branched-chain hydrocarbons have been reported as being resistant to microbial attack (Norris et al. 1994). This characteristic might allow a differentiation between straight-chain and branched-chain species which would suggest the operation of microbial action by indigenous microbial populations.

Four distinct (refractory) branched-chain hydrocarbons, which occurred between C_{12} and C_{15} in the chromatograms, were selected to serve as benchmarks for straight-chain/branch-chain degradation ratio assessment. Figure 4-5 is a chromatogram of a 500 μg/mL arctic diesel fuel standard obtained in Kotzebue, Alaska. The straight-chain hydrocarbons (C_9 through C_{16}) and the four branched-chain hydrocarbon benchmarks (B_1 through B_4) selected for evaluation are identified in the figure.

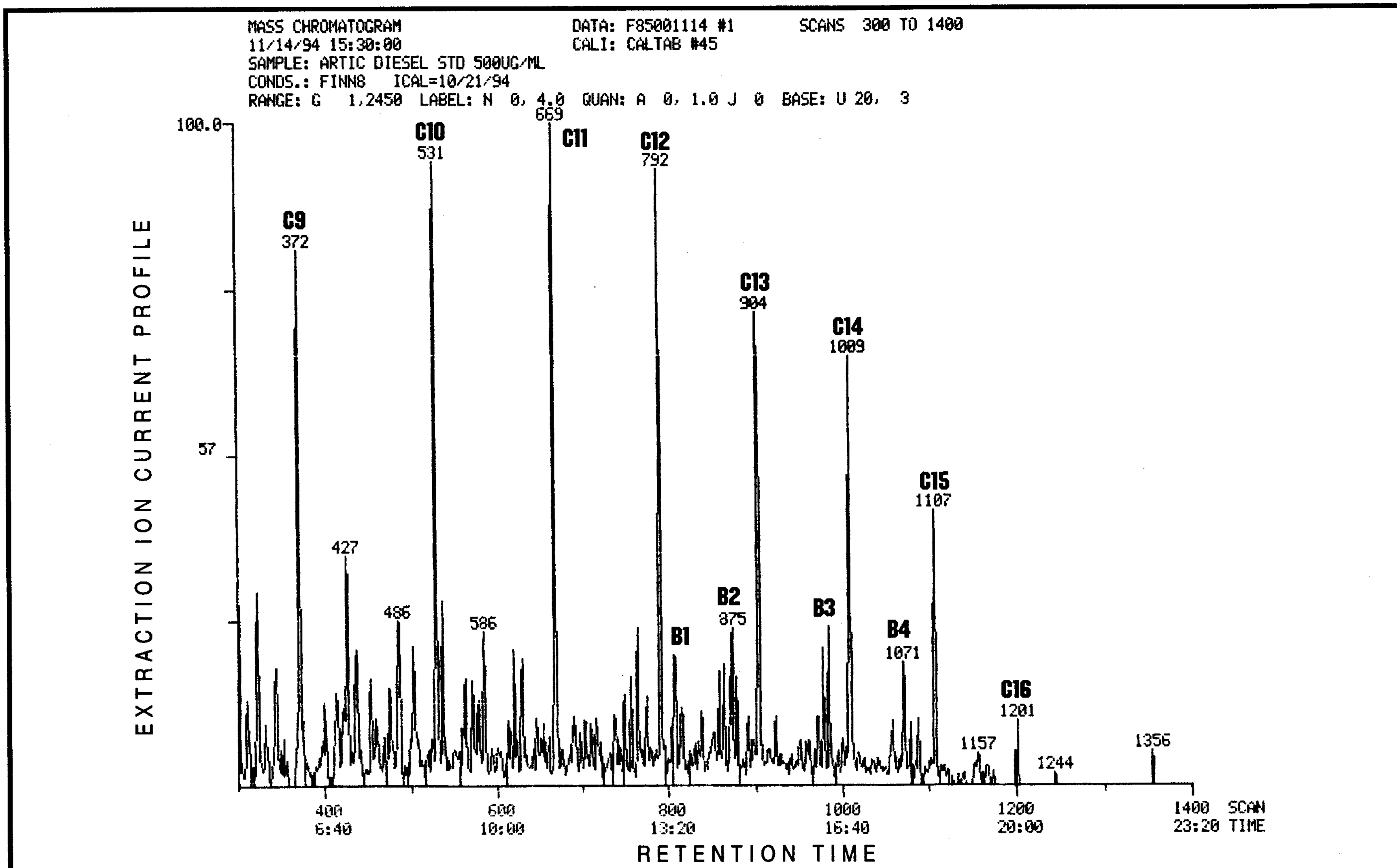

Figure 4-5. Chromatogram for Arctic Diesel Fuel Standard (500 µg/ml), 1994 Remedial Investigation, Kotzebue, Alaska.

A number of assumptions provide an underlying basis for the work conducted and conclusions drawn during this study:

- It is assumed that the sample of unweathered arctic diesel fuel collected from Kotzebue, Alaska is representative of the weathered arctic diesel encountered in the environmental samples taken on the site.

- It is assumed that one may depend on the literature reviewed and cited to support the statement that "branched chain alkanes are much more resistant to microbially mediated degradation than the associated straight chain alkanes" (Christensen and Larson 1993) and (Norris et al. 1994).

- It is assumed that the subset of environmental samples selected were: 1) meaningful in spatial distribution relative to the spill sites under investigation; and 2) contained TPH concentrations which allowed sufficient instrumental response to allow quantitation of peak areas without substantial concerns for statistical variability.

Analytical Methodology--For the purpose of this study, all samples were analyzed by GC/MS technique to obtain retention time, peak area, and speciation data for the individual hydrocarbons observed. Samples were first screened to determine approximate analyte levels so as not to overload the chromatographic column. A representative soil sample portion was then weighted, and extracted with methylene chloride. The resulting methylene chloride extract was then concentrated to a volume of one milliliter for instrumental analysis.

A one to two microliter aliquot was injected into the GC/MS. The constitution mass of 57 was chosen for this study to reduce other non-hydrocarbon interferences. Because arctic diesel was the expected contaminant, an arctic diesel analytical standard (collected from Kotzebue, Alaska) was first analyzed with a method blank, matrix spikes, and followed by the selected environmental site samples.

Identification of Branched Chain Alkanes--The Finnigan Mass Spec system allows for the computerized archiving of the ion fragments that are produced when the compounds in the sample pass through the instrument's detector stage. The data can be retrieved to a "snapshot" of the ion fragments

in the detector as the peak of interest elutes. The list of fragments and their abundances becomes a characteristic which is quite representative of an individual compound. The pattern of fragments can be computer matched against a library of over 50,000 compounds and the three best fits reported. The results of this exercise for the branched-chain peaks B1 through B4 provide two important outcomes. First, analysis of the ion patterns leads to the conclusion that the number of carbon atoms associated with B1 through B4 is likely to be: B1 = 13, B2 = 14, B3 = 15, and B4 = 16. Secondly, the most likely matches of library compounds confirm these conclusions and provide likely candidates for the compounds, although an unambiguous identification is not possible with the present information. The best fit between the "B" fragment pattern and the library compounds are presented as follows:

B1 6-methyl dodecane; 3,6-dimethyl undecane; 2,5-dimethyl undecane

B2 7-methyl tridecane; 4,6-dimethyl dodecane; tetradecane

B3 2,7,10-trimethyl dodecane; 2,6,11-trimethyl dodecane; 2,6,10-trimethyl dodecane

B4 hexadecane; 2-methyl-8-propyl dodecane; 7-propyl tridecane

The library matches indicate a consistent number of carbon atoms per molecule, which is expected from the order in which the "B" compounds elute from the column. Branched structures of varying degrees of complexity are the rule predominating selection from the library, with only 2 of 12 matches given as straight chain compounds.

Site/Soil Sample Selection Criteria--Two sites characterized during the Kotzebue LRRS 1994 remedial investigation were selected to evaluate natural attenuation of petroleum hydrocarbon contamination in soils, including Sites ST05-Beach Tanks and SS12-Spills No. 2 and 3. These sites were selected because of the nature and extent of contamination [known and/or suspected diesel-fuel release(s)] and because previous IRP investigation results indicated these sites may potentially pose a risk to the environment. Sample selection criteria for each site location includes the following:

- Samples must reveal an elevated diesel range organics concentration to allow ratio comparison (i.e., >500 mg/kg). One background sample was selected to ensure that the branched-chain hydrocarbon benchmarks did not occur in native organic materials.

- Samples were selected along suspected contaminant flow paths to evaluate the degree of natural attenuation occurring adjacent to and removed from the suspected source area.

Three samples were selected for evaluation at each site based on the selection criteria given above. Samples selected at Site SS12-Spills No. 2 and 3 include SB15, SB20, and SB24. Samples selected at Site ST05-Beach Tanks includes SB22 (background), SB24, and SB08 (Figure 4-6). General information for the selected samples is provided below:

Sample Identification	Sample Depth (feet-BGS)	Original Diesel Range Organics Results (mg/kg)	Sample Description
SS12-SB15	1.5	42,000	clayey Silt (native tundra)
SS12-SB20	1.0	30,000	clayey Silt (native tundra)
SS12-SB24	1.0	1,900	clayey Silt (native tundra)
ST05-SB22	8.5	3.9	sandy Gravel
ST05-SB24	8.0	18,000	sandy Gravel
ST05-SB08	4.0	9,000	gravelly Sand

Results of the natural attenuation assessment for soils at Kotzebue are discussed in Section 4.6.6, Natural Attenuation Assessment Results.

4.4.9.2 Near-Beach Groundwater Flowpath. Naturally occurring subsurface attenuation processes including both destructive (e.g., biodegradation, aerobic oxidation, and hydrolysis) and nondestructive (e.g., sorption, dilution, and volatilization) mechanisms can bring about a reduction in the total mass of contaminant dissolved in groundwater (Wiedermeier et al. 1994). The geochemical relationship between groundwater and contamination as groundwater moves through a contamination source area can provide a means to determine if natural attenuation is active, and to what extent biodegradation may be responsible for a reduction in contaminant concentrations in groundwater.

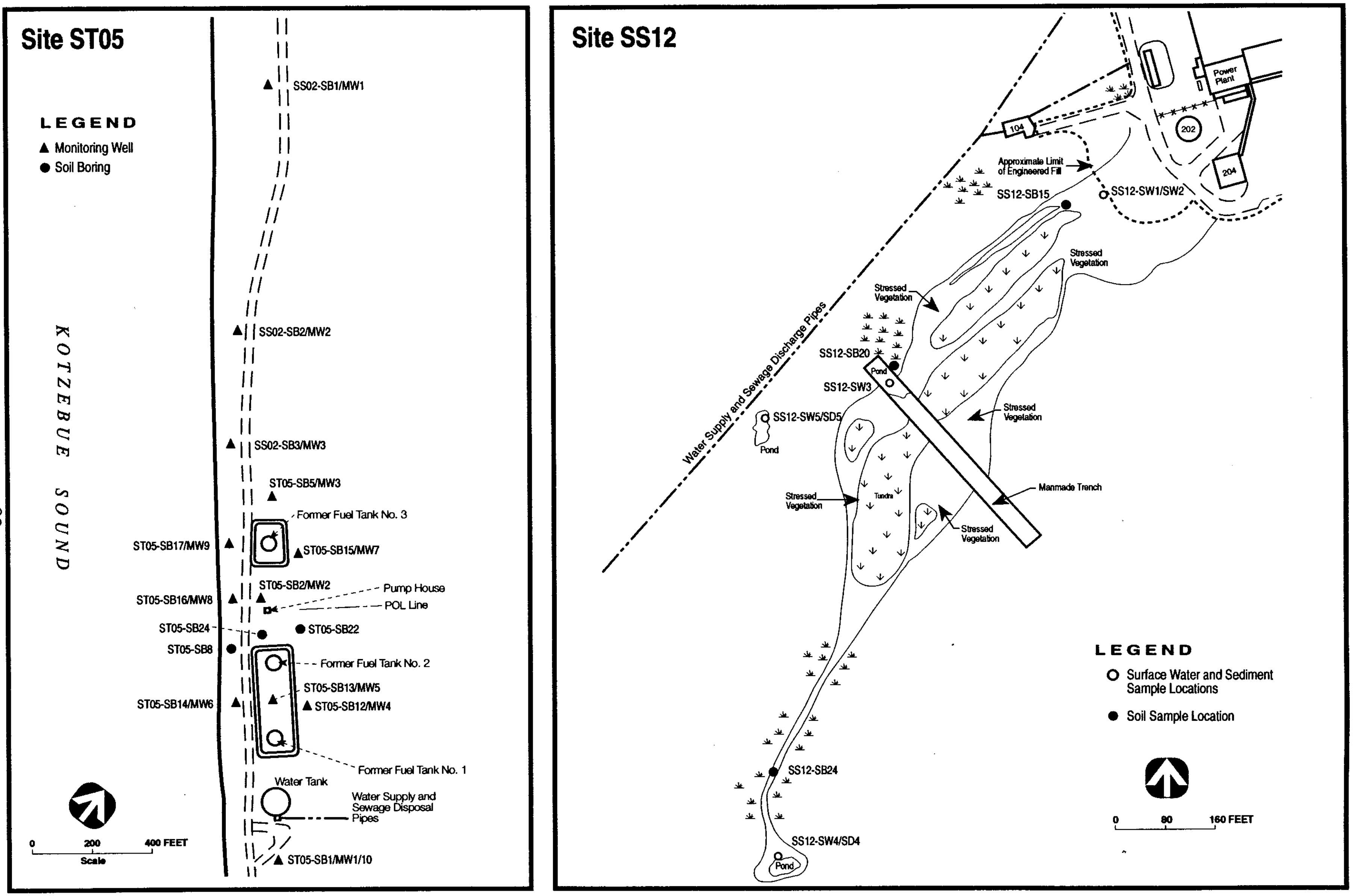

Figure 4-6. Natural Attenuation Assessment Sample Locations for Sites SS12 and ST05, 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

In 1992, the USAF removed three large fuel storage tanks located adjacent to Kotzebue Sound (see Section 3.4, Beach Tanks Removal). The former beach tanks and associated fuel supply system is the suspected source of near-beach aquifer contamination at Kotzebue LRRS.

A suite of geochemical parameters (see Table 4-6) was measured in near-beach groundwater samples obtained from monitoring wells located both upgradient and downgradient of the Beach Tank pads (see Figure 4-6). Four monitoring wells (ST05-MW6, MW8, MW9 and SS02-MW3) located within the fore-beach, three mid-beach monitoring wells (ST05-MW2, MW3, and MW5), and two back-beach monitoring wells (ST05-MW4 and MW7) were included in the geochemical groundwater investigation. Measured changes in groundwater geochemistry in the near-beach aquifer are discussed in Section 4.6.6, Natural Attenuation Assessment Results.

4.4.9.3 Surface Water Pathway. The geochemical relationship between surface water and contamination as surface water moves through a contamination source area can provide a means to determine if natural attenuation is active, and to what extent biodegradation may be responsible for a reduction in contaminant concentrations in surface water.

A suite of geochemical parameters (see Table 4-6) was measured in surface water samples used to evaluate natural attenuation along a 750 ft complex surface water drainage pathway at Site SS12 (see Figure 4-6). The Kotzebue LRRS facility is located on a topographic high, and an unaffected surface water sample from Site SS12 could not be located directly associated with the facility. A background surface water sample (e.g., collected from Background Station #2) was characterized for geochemical parameters (see Section 4.4.10, Background Characterization). A discussion regarding the occurrence of natural attenuation along the surface water flowpath at Site SS12 is provided in Section 4.6.6, Natural Attenuation Assessment Results.

4.4.10 Background Characterization

Previous field investigation activities conducted at Kotzebue LRRS did not include the collection and analysis of background samples. The concentration of contaminants detected in background samples collected during the 1994 field investigation provides the baseline concentration data necessary to evaluate site-specific samples collected from each media and source area during the remedial investigation. Background characterization included those analyses performed and media sampled during the 1994 remedial investigation (see Table 4-5). Figure 4-7 identifies background sample stations. A summary

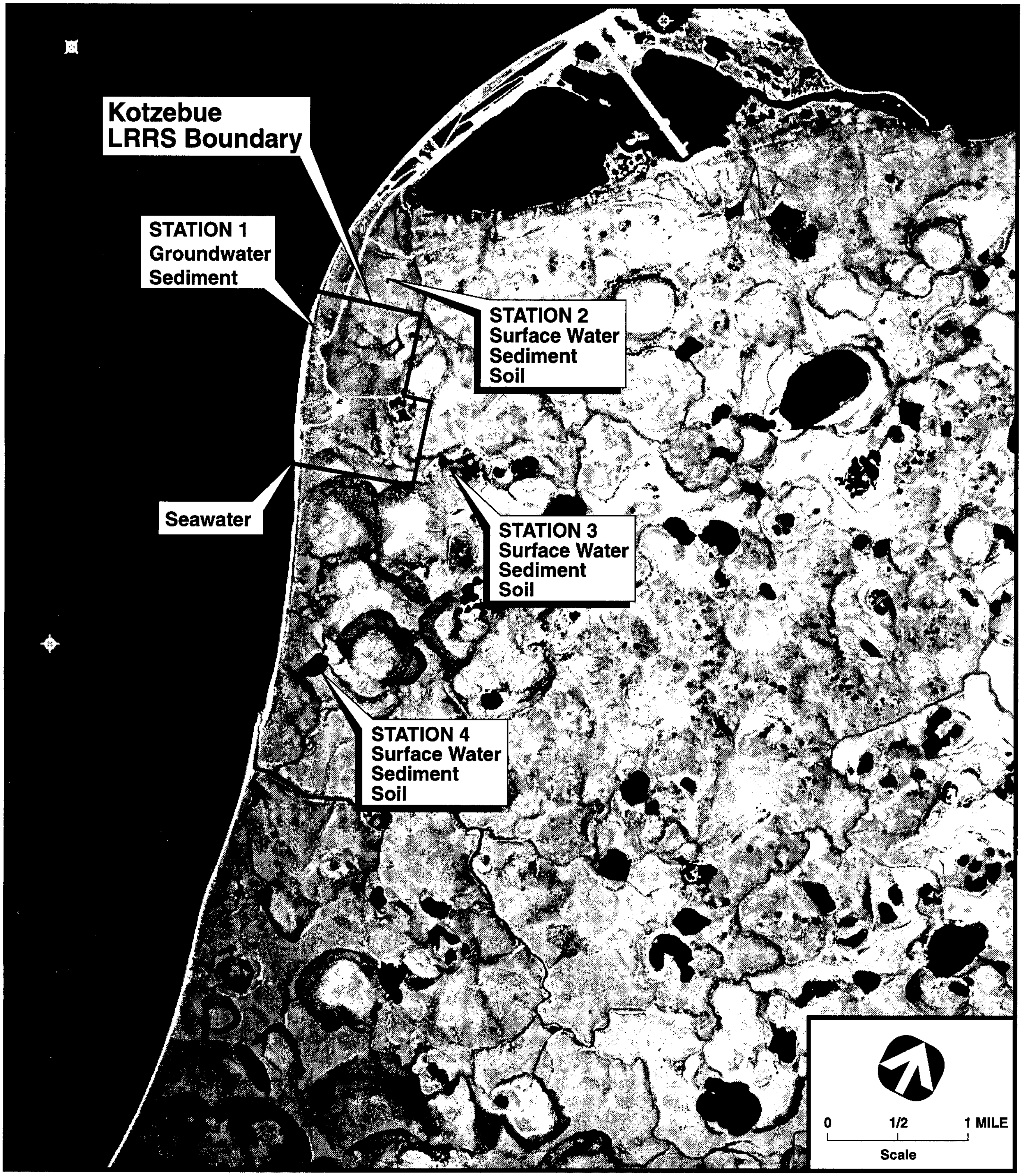

Figure 4-7. Background Sample Station Locations, 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

of maximum contaminant concentrations detected in background media is provided by analytical method in Section 4.5, Summary of Analytical Results). A discussion of analytical results associated with media specific background characterization is provided in Section 4.6.7, Background Characterization Results.

4.4.11 Sample Location Survey

All sample locations were identified with a marking flag bearing the sample designation during the Kotzebue LRRS 1994 RI. Marking flags were placed at the time of sample collection and remained in place until the sample locations were surveyed. Background sample locations were not surveyed due to their limited access and distance from the site. Access was provided to all groundwater monitoring wells installed at Kotzebue LRRS for well location and elevation survey.

Surveying was conducted between 25 July and 27 July 1994 by the USAF 611 CES/CECC. Surveying control points (benchmarks) used by the 611 CES/CECC for survey data were similar to those used during the previous IRP investigation conducted at Kotzebue LRRS, including U.S. Core of Engineers (COE) benchmarks COE "BAG" and COE B.C. MON "BAT". The use of COE control points provided for direct correlation to previous work performed at the site. However, the 611 CES/CECC has determined that the surface elevation provided on COE, "BAT" was a relative elevation that cannot be referenced directly to a common datum (i.e., Mean Sea Level). Therefore, all sample survey elevations for Kotzebue LRRS are reported as relative to COE, BAT.

Longitude and latitude coordinates for all sample locations were surveyed to within 0.5 feet. The ground surface elevation at each location was surveyed to ± 0.1 feet. The elevation of all newly installed monitoring wells was surveyed to within ± 0.01 feet at the water level measuring point (notch) on the top of the well casing (TOC). Survey data was recorded using the COE reference. All horizontal coordinates have been converted by the 611 CES/CECC to the state-plane coordinate system (reference NAD'83; AK7). Sample location survey data measured during the Kotzebue LRRS 1994 remedial investigation is provided in Appendix C.

4.4.12 Investigation Derived Waste Management

The minimization of investigation derived wastes (IDW) was an important objective during the planning and execution of field sampling activities at Kotzebue LRRS. Decontamination of field equipment, subsoil sampling, groundwater monitoring well development, and groundwater sampling all generated IDW, including wastewater, soils, used personal protective equipment, and field test kit residuals. Additionally,

an interim remedial action conducted at Site SSO2-Waste Accumulation Area No. 2/Landfill generated tar laden soil/product material and waste drums. A detailed description of IDW management is provided in the Kotzebue LRRS Work Plan (USAF 1994a).

All IDW were containerized in 55, 85, and 110 gal drums, segregated by type and matrix (soil, wastewater, etc.), properly labeled, stored within a secure onsite containment area, and inventoried (Table 4-11). At the completion of RI/FS field activities, decontamination wastewater was treated using an in-field carbon filtration system, recontainerized, and sampled for DROs (Method AK102), VOCs (EPA Method 8260), SVOCs (EPA Method 8270), and pesticides/PCBs (EPA Method 8081). In addition, wastewater generated during monitoring well development and groundwater sampling activities was treated using the carbon filtration system and sampled for VOCs (EPA Method 8260), SVOCs (EPA Method 8270), and TPH (Method AK102). At the completion of the 1994 field effort all IDW drums were moved and stored in the garage area of the Composite Facility. The garage area was secured and locked during demobilization as directed by the 611th CES.

On 23 September 1994, a technical memorandum was submitted to the AFCEE and 611th CES regarding the evaluation of IDW and disposal alternative recommendation for wastes stored at Kotzebue LRRS. In order to determine appropriate IDW disposition in accordance with state and federal regulations, sample analytical results were evaluated to: 1) determine if constituents are classified as a hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA); and 2) compare against established state and federal health-based standards. Based on a review of the analytical data, including TCLP analyses of tar wastes at Site SS02, none of the IDW are classified as RCRA regulated (hazardous) wastes based on toxicity. Results of TCLP analyses at Site SS02 are included in Appendix L. Diesel range organics detected at low concentrations in treated decontamination wastewater and treated groundwater samples exceed the Alaska Department of Environmental Conservation (ADEC) water quality criteria at 0.015 mg/L. However, remedial investigation results indicate that surface water DRO concentrations at the site far exceed DRO concentrations in treated wastewaters. Based on the evaluation of IDW at Kotzebue LRRS the 611 CES requested ADEC approval for onsite discharge of carbon-treated wastewaters (approximately 1,100 gallons) stored at Kotzebue LRRS. Based on review of available information the ADEC granted approval to the 611 CES for onsite discharge of treated wastewaters.

An inventory of IDW contained and stored at Kotzebue LRRS is provided in Table 4-11. IDW inventoried drums 1 through 21 formerly contained treated wastewaters. During the October 1994 interim

TABLE 4-11. KOTZEBUE LRRS INVESTIGATION DERIVED WASTES DRUM INVENTORY, 1994 REMEDIAL INVESTIGATION, KOTZEBUE LRRS, ALASKA
(Page 1 of 2)

Drum Inventory Identification	Contents	Origin	Matrix/Disposition	Generation Date	Treatment Date
1	Decontamination Wastewater	Decon	Treated Water	6/22/94	7/27/94
2	Decontamination Wastewater	Decon	Treated Water	6/22/94	7/27/94
3	Decontamination Wastewater	Decon	Treated Water	6/22/94	7/27/94
4	Decontamination Wastewater	Decon	Treated Water	6/22/94	7/27/94
5	Decontamination Wastewater	Decon	Treated Water	6/22/94	7/27/94
6	Decontamination Wastewater	Decon	Treated Water	6/22/94	7/27/94
7	Decontamination Wastewater	Decon	Treated Water	7/28/94	7/27/94
8	ST05-MW2 ST05-MW3, SS02-MW3, ST05-MW7, MW8, MW9	Development Purge Purge	Treated Water Treated Water Treated Water	7/8/94 7/19/94 7/19/94	7/27/94
9	ST05-MW2 ST05-MW1, MW2, MW4, MW5, MW6	Development Purge	Treated Water Treated Water	7/12/94 7/17/94	7/27/94
10	SS02-MW1 ST05-MW1	Development Development	Treated Water Treated Water	7/6/94 7/8/94	7/27/94
11	ST05-MW1	Development	Treated Water	7/8/94	7/27/94
12	ST05-MW5	Development	Treated Water	7/11/94	7/27/94
13	SS02-MW2, MW3 ST05-MW2	Development Development	Treated Water Treated Water	7/6/94 7/8/94	7/28/94
14	SS02-MW2, MW3	Development	Treated Water	7/14/94	7/28/94
15	ST05-MW4	Development	Treated Water	7/8/94	7/28/94
16	ST05-MW4	Development	Treated Water	7/8/94	7/28/94
17	ST05-MW8, MW9	Development	Treated Water	7/12/94	7/28/94
18	ST05-MW6	Development	Treated Water	7/11/94	7/28/94
19	ST05-MW7	Development	Treated Water	7/15/94	7/28/94
20	ST05-MW3	Development	Treated Water	7/8/94	7/28/94
21	ST05-MW7	Development	Treated Water	7/13/94	7/28/94
22	Carbon Treatment Unit (Westates Aqua Scrub)	Treatment Unit	Carbon/Water	7/27-28/94	NA
23	Used Personal Protection Gear/ Used Dexsil PCB Test Kits	7/24 Tar Cap & 7/28 Removal Test Kit Use	PPE/Test Kit Residuals	7/24-28/94	NA
24	ST05-SB2, SB3, SB4, SB10, SB14	Soil Borings	Soils	6/28/94-7/9/94	NA
25	ST05-SB1, SB11, SB12, SB15, SB18, SB19, SB22 Background SB1	Soil Borings	Soils	6/27/94-7/13/94	NA

TABLE 4-11. KOTZEBUE LRRS INVESTIGATION DERIVED WASTES DRUM INVENTORY, 1994 REMEDIAL INVESTIGATION, KOTZEBUE LRRS, ALASKA
(Page 2 of 2)

Drum Inventory Identification	Contents	Origin	Matrix/Disposition	Generation Date	Treatment Date
26	ST05-SB16, SB20, SB21	Soil Borings	Soils	7/10-12/94	NA
27	ST05-SB5, SB6, SB7, SB8, SB9 SS02-SB1, SB2, SB3	Soil Borings	Soils	6/29-30/94	NA
28	ST05-SB13, SB17	Soil Borings	Soils	7/9-13/94	NA
Interim Remedial Action Wastes					
29	SS02 Waste Accumulation Area Tar Trench Removal Action	Tar Removal	Tar and Soils (mixed)	7/24/94	NA
30	SS02 Waste Accumulation Area Tar Trench Removal Action	Tar Removal	Tar and Soils (mixed)	7/24/94	NA
6 55-gallon drums	SS02 Waste Accumulation Area Tar Trench Removal Action	Tar Removal	Tar and Soils (mixed)	10/27/94	NA
13 85-gallon drums	SS02 Waste Accumulation Area Tar Trench Removal Action	Tar Removal	Tar and Soils (mixed)	10/27/94	NA
10 85-gallon drums	SS02 Waste Accumulation Area Tar Trench Removal Action	Tar Removal	Tar product/drums	10/27/94	NA
13 110-gallon drums	SS02 Waste Accumulation Area Tar Trench Removal Action	Tar Removal	Tar product/drums	10/27/94	NA
17 55-gallon drums	SS02 Waste Accumulation Area Tar Trench Removal Action	Tar Removal	Empty (partially crushed) removed from excavation	10/27/94	NA

Shading indicates IDW were disposed and are no longer stored at the LRRS facility.

remedial action conducted at Kotzebue LRRS, all treated wastewaters were discharged to site soils located adjacent to the complex facility garage area. The volume of specific IDW presently stored at Kotzebue LRRS include approximately, 275 gallons of soil cuttings, 1,450 gallons of asphaltic tar/soil admixture, 850 gallons of tar product, and empty waste drums removed from the tar disposal trench.

4.4.13 Interim Remedial Action

During the 1994 remedial investigation, a tar disposal trench was discovered within the former facility landfill located adjacent to Kotzebue Sound. Initial reconnaissance of the site identified a 3 feet by 9 feet area, approximately one-foot deep, consisting of a black, tarry substance of unknown composition. The carcasses of two ground squirrels were observed trapped in the substance.

The USAF immediately issued an Interim Remedial Action (IRA) to characterize and excavate the material that was exposed to contact with humans and wildlife. The IRA was conducted at Kotzebue LRRS in late July 1994 and included limited excavation of tar and associated soil materials from the disposal trench. The USAF conducted Toxicity Characteristic Leaching Procedure (TCLP) analyses of the tar-like substance to evaluate its chemical properties. Analytical results indicated that the substance was not a hazardous material based on toxicity (see Appendix L). The USAF believes the material is asphalt "cut-back" used during the construction of the asphalt pads which supported the three large fuel tanks formerly located along the beach area to the west of the main radar facility.

During the initial excavation of the tar material the USAF discovered the existence of both empty and partially filled 55-gallon drums containing tar waste. Based on this discovery of additional wastes, the USAF secured the site and began planning a second phase IRA designed to remove and contain all residual wastes within the disposal trench.

The USAF conducted the supplemental (second phase) IRA between 03 October and 08 October 1994 to complete the removal of tar wastes and buried drums associated with the tar disposal trench. The results of the IRA included the removal and containment of approximately 1,433 gallons of tar laden soils, 850 gallons of tar product, and 17 empty, partially crushed 55-gallon drums (see Section 4.12, Investigation Derived Waste Management). Two soil samples were collected from the bottom of the excavation at the completion of the removal action. The samples were analyzed for total petroleum hydrocarbons, and the effectiveness of the cleanup was verified when no residual contamination was detected in either soil sample (see Appendix L; Site SS02).

4.5 SUMMARY OF ANALYTICAL RESULTS

Site-specific analytical results for soils and sediments collected at Kotzebue LRRS during the 1994 RI are summarized by analytical method in Tables 4-12 through 4-16. Site-specific analytical results for groundwater and surface waters collected at Kotzebue LRRS are summarized by analytical method in Tables 4-17 through 4-21. All analytical results presented in Tables 4-12 through 4-21 are summarized as site-specific maximum concentrations, and are based on the site-specific analyses and associated media specified in Table 4-5. The contaminant analysis summary tables include all compounds detected in environmental samples collected during the 1994 remedial investigation at Kotzebue LRRS. Regulatory criteria presented in Tables 4-12 through 4-21 are identified as applicable to detected compounds. If a regulatory criteria is exceeded, the criteria and associated compound are identified by shading. Sample specific analytical results are presented by site in Appendix L.

Analytical results presented in Tables 4-12 through 4-21 include data qualifiers as reported by the laboratory. Definitions for laboratory reported data qualifiers include the following for both organic and inorganic analyses:

Organic Compound Data Reporting Qualifiers	
ND	Indicates the compound was undetected at the reported concentration.
J	Indicates an estimated value when the value is less than the Practical Quantitation Limit (PQL) but greater than the Method Detection Limit (MDL).
E,K	Indicates a value above the linear range of the detector. Sample dilution required.
Q	Indicates an estimated value of analyte found and confirmed by analyst but with low spectral match.
B	Indicates possible/probable blank contamination. Flagged when the analyte is detected in the blank as well as the sample.
X	For Pesticides/PCBs: In the opinion of the analyst, the relevant compound was not actually present in the sample, even though it is detected in the sample on both columns, within each compound's respective set of retention time windows.
Inorganic Compound	
"B"	Indicates element detected in sample or blank above MDL but below PQL.

TABLE 4-12. SUMMARY OF MAXIMUM VOLATILE ORGANIC COMPOUND CONCENTRATIONS DETECTED IN SOIL AND SEDIMENT SAMPLES COLLECTED DURING 1994 REMEDIAL INVESTIGATION AT KOTZEBUE LRRS

Site Designation	Range of Sample Depths (ft-below ground surface)	Maximum Detected Volatile Organic Compounds (mg/kg)															
		Methylene Chloride	Acetone	Carbon Disulfide	cis-1,2-Dichloro-ethene	Chlor-oform	2-Buta-none	1,1,1-Tri-chloro-ethane	Tri-chloro-ethene	4-Methyl-2-Pentanone (MIBK)	Tetra-chloro-ethene	Chloro-benzene	1,1,2-Tri-chlorotri-fluoroethane	Benzene	Ethyl-benzene	Toluene	Total Xylenes
SS13 (AOC1)	0.75-4.0	0.28**JB**	0.72JQ	ND	0.002**J**	ND	0.005**J**	ND	0.001JQ	ND	0.027	ND	ND	ND	0.53	0.37**J**	28
AOC2	1.5-3.5	0.17**JB**	0.62**JB**	ND	0.024	ND	0.59JQ	ND	0.002**J**	ND	ND	ND	ND	ND	0.0006**J**	0.0011**J**	0.006**J**
SS14 (AOC3)	1.5-3.0	0.26**JB**	0.66**J**	ND	ND	ND	0.37JQ	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.88
SS15 (AOC4)	1.0-7.0	0.29**JB**	ND	ND	ND	ND	ND	0.098JQ	0.096JQ	ND	ND	ND	ND	ND	ND	ND	1.6Q
AOC5	0.5-3.5	0.46**JB**	1.4**J**	ND	ND	0.077	0.65JQ	ND	0.49	ND	ND	ND	ND	0.1	1.8	1.7	35
SS16 (AOC6)	1.0-3.0	0.34**JB**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0014**J**	ND
AOC7	1.0	0.004	0.02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0013**J**	ND
AOC8	1.0-3.5	0.012**JBQ**	0.01**JB**	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.002**JB**	ND	ND	0.0013**J**	0.004**J**
ST04 (AOC9)	1.5-2.0	0.22**J**	1.4**J**	ND	ND	ND	0.45**J**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AOC10	--	0.055**JB**	2.0	0.04Q	ND	ND	0.78	ND	ND	0.085**JQ**	ND	ND	ND	ND	1.1	24	11
SS18 (AOC11)	0.5-2.0	0.30**J**	0.90**JB**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SS19 (AOC12)	0.5	0.012**B**	0.01**JB**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SS02	0.5	0.002**JB**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0008**J**	ND	0.007
ST05	0.5-13.0	0.39**B**	1.2**JB**	ND	ND	ND	0.74JQ	ND	ND	ND	ND	0.27**J**	ND	ND	0.54**J**	ND	23
SS07	0.5	0.003**JB**	0.16	ND	ND	ND	0.068	ND	ND	ND	ND	ND	ND	ND	0.0007**JQ**	ND	0.010**J**
SS08	1.0-1.5	0.003**JB**	0.03	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SS11	0.5-1.0	0.010**B**	0.03**B**	ND	ND	ND	0.009	ND	0.002JQ	ND	ND	ND	0.002**JB**	ND	0.0012**J**	0.099	0.014
SS12	0.5-7.8	0.6**JB**	3.5**B**	ND	ND	ND	0.51JQ	ND	1.0	ND	ND	0.098**J**	ND	1.6	23	52	440
Background	0.5-11.0	0.021**JB**	0.24	ND	ND	ND	0.037	ND	ND	ND	ND	ND	ND	ND	0.002	0.094	0.014
Practical Quantitation Limit	--	0.003	0.01	0.002	0.004	0.001	0.008	0.001	0.002	0.005	0.003	0.002	0.002	0.0015	0.0014	0.0029	0.003
RCRA Toxicity Characteristic (mg/L)	--	--	--	--	--	--	200	--	--	--	--	100	--	--	--	--	--

ND = Compound non-detected at practical quantitation limit.
-- = Not applicable.
Data Qualifiers: J, B, Q indicate data qualifiers as applied by the laboratory and defined in Section 4.5.

TABLE 4-13. SUMMARY OF MAXIMUM SEMIVOLATILE ORGANIC COMPOUND CONCENTRATIONS DETECTED IN SOIL AND SEDIMENT SAMPLES COLLECTED DURING 1994 REMEDIAL INVESTIGATION AT KOTZEBUE LRRS (Page 1 of 2)

Site Designation	Range of Sample Depths (ft-below ground surface)	Maximum Detected Semivolatile Organic Compounds (mg/kg)													
		Phenol	1,4-Di-chloro-benzene	Benzyl Alcohol	4-Methyl-phenol	Iso-phorone	Benzoic Acid	Naph-thalene	4-Chloro-aniline	2-Methyl-naph-thalene	2-Nitro-aniline	Dimethyl-phthalate	Acenaph-thene	4-Nitro-phenol	Dibenzo-furan
SS13 (AOC1)	0.75-4.0	ND	ND	ND	ND	ND	0.24	2.4	ND	2.5	ND	ND	ND	ND	ND
AOC2	1.5-3.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SS14 (AOC3)	1.5-3.0	ND	ND	ND	ND	ND	ND	ND	ND	11	ND	ND	ND	ND	ND
SS15 (AOC4)	1.0-7.0	ND	ND	ND	ND	ND	ND	22	ND	52	ND	ND	1.0Q	11	1.2JQ
AOC5	0.5-3.5	0.1J	ND	ND	0.5	ND	0.18J	23	ND	57	ND	ND	0.9J	ND	1.2JQ
SS16 (AOC6)	1.0-3.0	ND	ND	ND	ND	ND	ND	ND	ND	1.0	ND	ND	0.6	ND	ND
AOC7	1.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AOC8	1.0-3.5	0.2JQ	ND	ND	1.2	ND	ND	0.5Q	ND	0.7Q	ND	ND	ND	ND	ND
ST04 (AOC9)	1.5-2.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.1JQ	ND	ND	ND
AOC10	NA	69	46	ND	82	ND	ND	6.3Q	9.0	1.6J	ND	ND	0.9J	ND	ND
SS18 (AOC11)	0.5-2.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SS19 (AOC12)	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SS02	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ST05	0.5-13.0	ND	ND	ND	ND	2.8	ND	18	ND	55	ND	ND	0.6JQ	ND	0.9JQ
SS07	0.5	ND	ND	ND	ND	ND	0.76	ND	ND	ND	ND	ND	ND	ND	ND
SS08	1.0-1.5	ND	ND	ND	ND	ND	ND	25	ND	59	8.7	ND	2.8Q	ND	2.9Q
SS11	0.5-1.0	ND	ND	ND	0.3JQ	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SS12	0.5-7.8	0.1J	ND	ND	0.7JQ	ND	0.32JQ	32	ND	95	ND	ND	3.5	ND	3.0
Background	0.5-11.0	ND	ND	0.1JQ	ND	ND	1.0J	ND	ND	ND	ND	ND	ND	ND	ND
Practical Quantitation Limit	--	0.2	0.1	0.2	0.2	0.1	0.18	0.1	0.3	0.1	0.06	0.1	0.1	0.21	0.1
RCRA Toxicity Characteristic (mg/L)	--	--	7.5	--	--	--	--	--	--	--	--	--	--	--	--

TABLE 4-13. SUMMARY OF MAXIMUM SEMIVOLATILE ORGANIC COMPOUND CONCENTRATIONS DETECTED IN SOIL AND SEDIMENT SAMPLES COLLECTED DURING 1994 REMEDIAL INVESTIGATION AT KOTZEBUE LRRS
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Site Designation	Range of Sample Depths (ft-below ground surface)	Maximum Detected Semivolatile Organic Compounds (mg/kg)														
		Fluorene	Phenanthrene	Anthracene	Di-n-Butylphthalate	Fluoranthene	Pyrene	Butylbenzylphthalate	Benzo(a)-anthracene	bis(2-Ethylhexyl) phthalate	Chrysene	Benzo(b)-fluoranthene	Benzo(k)-fluoranthene	Benzo(a) pyrene	Indeno-(1,2,3-cd)-pyrene	Benzo-(g,h,i)-perylene
SS13 (AOC1)	0.75-4.0	0.1J	0.1J	ND	ND	0.04J	0.1J	ND	ND	0.6B	ND	ND	ND	ND	0.04JQ	0.04JQ
AOC2	1.5-3.5	0.2Q	0.1J	ND	ND	ND	0.1J	ND	ND	0.3	ND	ND	ND	ND	ND	ND
SS14 (AOC3)	1.5-3.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SS15 (AOC4)	1.0-7.0	1.7	0.7J	ND	ND	ND	ND	ND	ND	1.4J	ND	ND	ND	ND	ND	ND
AOC5	0.5-3.5	1.8	1.0J	ND	0.1J	0.9J	0.9J	2.9	ND	2.9	ND	ND	ND	ND	ND	ND
SS16 (AOC6)	1.0-3.0	12Q	0.6JQ	ND	ND	0.6J	0.9Q	ND	ND	2.4	ND	ND	ND	ND	ND	ND
AOC7	1.0	ND	ND	ND	ND	ND	ND	ND	ND	1.2	ND	ND	ND	ND	ND	ND
AOC8	1.0-3.5	ND	0.1J	ND	ND	0.1	0.1	ND	0.1J	0.8	0.1J	0.1J	ND	0.1J	ND	ND
ST04 (AOC9)	1.5-2.0	ND	ND	ND	ND	ND	ND	ND	ND	0.6	ND	ND	ND	ND	ND	ND
AOC10	--	1.1J	4.4	2.0J	2.4JQ	5.0	5.2	ND	3.4	61	4.1	2.4J	3.5J	3.0J	1.4J	1.4J
SS18 (AOC11)	0.5-2.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SS19 (AOC12)	0.5	ND	ND	ND	ND	ND	ND	ND	ND	3.8J	ND	ND	ND	ND	ND	ND
SS02	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ST05	0.5-13.0	1.7	0.9J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SS07	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SS08	1.0-1.5	6.3	2.0	ND	ND	1.2J	1.2	ND	ND	0.8	ND	ND	ND	ND	ND	ND
SS11	0.5-1.0	ND	ND	ND	ND	ND	ND	ND	ND	0.4	ND	ND	ND	ND	ND	ND
SS12	0.5-7.8	4.2	5.4	0.8J	ND	1.7	1.1	ND	0.05J	2.4	0.1J	ND	ND	ND	ND	ND
Background	0.5-11.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Practical Quantitation Limit	--	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1
RCRA Toxicity Characteristic (mg/L)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

ND = Compound non-detected at practical quantitation limit. -- = Not applicable.
Data Qualifiers: J and Q indicate data qualifiers as applied by the laboratory and defined in Section 4.5.

TABLE 4-14. SUMMARY OF MAXIMUM PESTICIDES/PCBs CONCENTRATIONS DETECTED IN SOIL AND SEDIMENT SAMPLES COLLECTED DURING 1994 REMEDIAL INVESTIGATION AT KOTZEBUE LRRS
(Page 1 of 2)

Site Designation	Range of Sample Depths (ft-below ground surface)	Maximum Detected Pesticides/PCBs Compounds (mg/kg)											
		Alpha-BHC	Beta-BHC	Delta-BHC	Gamma-BHC (Lindane)	Heptachlor	Aldrin	Heptachlor Epoxide	Endosulfan I	Dieldrin	4,4'-DDE	4,4'-DDD	4,4'-DDT
SS13 (AOC1)	0.75-4.0	0.0020X	0.0074X	0.013X	0.0078X	ND	0.0089X	0.054X	0.0032X	0.0005X	0.021	0.31	0.082
AOC2	1.5-3.5	ND	ND	ND	ND	ND	ND	0.013X	ND	ND	0.26	0.29	2.0
SS14 (AOC3)	1.5-3.0	ND	0.0026X	0.11X	0.0019X	0.0022X	ND	0.0056X	0.00036JX	ND	0.0055	0.018	0.088
SS15 (AOC4)	0.5-1.0	0.0018X	ND	ND	0.0015X	0.0011X	0.0026X	ND	ND	0.0024X	0.0028	0.0073	0.0026
AOC5	0.5-2.5	0.0036	0.0055	0.20	0.003	0.002	0.0021	0.17	ND	0.0016	1.2	6.4	0.53
SS16 (AOC6)	1.0-3.0	0.018X	0.002X	ND	0.0053X	0.023X	0.0025X	0.0024X	0.0011X	ND	0.30X	0.54	0.41
AOC7	1.0	ND	ND	ND	ND	ND	ND	0.00092X	ND	ND	0.2	0.98	0.73
AOC8	1.0-3.5	0.003X	0.74X	ND	ND	ND	0.00051X	ND	ND	0.0057X	0.04	0.26	0.15
ST04 (AOC9)	1.5-2.0	0.0021X	ND	ND	ND	ND	ND	ND	ND	0.0006X	0.13	0.19	0.47
AOC10	NA	0.16X	ND	ND	ND	ND	ND	0.026	ND	0.42X	0.61	0.30	0.20X
AOC12	0.5	ND	ND	0.062X	ND	ND	0.046X	0.017X	ND	ND	ND	ND	0.12X
SS02	0.5	0.0055X	ND	0.11X	ND	ND	ND	ND	ND	ND	0.099	0.057	0.40
ST05	0.5	ND	ND	0.0018X	ND	ND	ND	ND	ND	ND	0.046	0.35	2.8
SS07	0.5	0.017X	ND	0.0056X	0.032X	ND	ND	0.12X	ND	ND	0.12	3.1	0.65
SS08	0.5	0.016X	ND	0.0012X	ND	ND	ND	ND	ND	ND	0.054	0.18	0.26
SS11	0.5-1.0	0.07X	0.07X	0.06X	ND	ND	ND	ND	ND	ND	1.1	1.3	5.3
SS12	0.5-1.0	0.13	0.19X	0.083	0.0085X	0.05X	0.05X	0.39X	ND	0.03X	0.43	1.1	2.7
Background	0.5	0.0032X	0.014X	ND	0.011X	ND	ND	0.0084X	0.0086X	0.002X	0.0039	0.022	0.050
Practical Quantitation Limit	--	0.00020	0.00031	0.00032	0.00025	0.0003	0.00020	0.00025	0.00036	0.0004	0.0003	0.0004	0.0007
RCRA Toxicity Characteristic (mg/L)	--	--	--	--	0.4	0.008	--	0.008	--	--	--	--	--
EPA Region 10 PCB Target Level	--	--	--	--	--	--	--	--	--	--	--	--	--

TABLE 4-14. SUMMARY OF MAXIMUM PESTICIDES/PCBs CONCENTRATIONS DETECTED IN SOIL AND SEDIMENT SAMPLES COLLECTED DURING 1994 REMEDIAL INVESTIGATION AT KOTZEBUE LRRS
(Page 2 of 2)

Site Designation	Range of Sample Depths (ft-below ground surface)	Maximum Detected Pesticides/PCBs Compounds (mg/kg)							
		Endrin	Endosulfan II	Methoxychlor	Endrin Aldehyde	Gamma Chlordane	Alpha Chlordane	Arochlor 1254	Arochlor 1260
SS13 (AOC1)	0.75-4.0	0.0046	ND	ND	ND	0.00058X	0.00044X	ND	ND
AOC2	1.5-3.5	0.012X	ND	ND	ND	ND	ND	ND	ND
SS14 (AOC3)	1.5-3.0	0.0005X	ND	0.0019JX	0.0027X	0.0045X	0.0014X	ND	ND
SS15 (AOC4)	0.5-1.0	0.001X	ND	ND	ND	0.00067X	ND	ND	ND
AOC5	0.5-2.5	0.0045	ND	ND	0.0021	0.0018	0.0013	ND	ND
SS16 (AOC6)	1.0-3.0	0.056X	ND	0.0016JX	0.0008X	0.0022X	0.00017X	0.03J	0.01J
AOC7	1.0	0.0074	ND	ND	ND	ND	ND	ND	ND
AOC8	1.0-3.5	0.17	ND	3.5X	ND	0.014X	ND	ND	8.4E
ST04 (AOC9)	1.5-2.0	0.036X	ND	3.4	ND	ND	ND	ND	0.07
AOC10	--	0.12X	0.43	0.15JX	ND	ND	ND	4.2	2.2
SS19 (AOC12)	0.5	ND	ND	ND	ND	ND	ND	ND	ND
SS02	0.5	0.0028X	ND	ND	ND	ND	ND	ND	ND
ST05	0.5	0.0069X	ND	ND	ND	ND	ND	ND	ND
SS07	0.5	0.043X	ND	ND	ND	ND	ND	ND	ND
SS08	0.5	0.011X	ND	ND	ND	0.00024X	ND	ND	ND
SS11	0.5-1.0	0.035X	ND	ND	ND	0.01X	ND	ND	2.7
SS12	0.5-1.0	0.053X	ND	ND	0.0004JX	0.0025X	0.0031	ND	0.96J
Background	0.5	0.0024X	ND	0.043	0.0014X	0.0026X	0.026J	ND	0.02J
Practical Quantitation Limit	--	0.0003	0.0005	0.0027	0.0003	0.00017	0.0002	0.03	0.03
RCRA Toxicity Characteristic (mg/L)	--	0.02	--	10	--	0.03	0.03	--	--
EPA Region 10 PCB Target Level (mg/kg)	--	--	--	--	--	--	--	10	10

ND = Compound non-detected at the practical quantitation limit. -- = Not applicable.
Data Qualifiers: X, J, E indicate data qualifiers as applied by the laboratory and defined in Section 4.5.

TABLE 4-15. SUMMARY OF MAXIMUM METALS CONCENTRATIONS DETECTED IN SOIL AND SEDIMENT SAMPLES COLLECTED DURING 1994 REMEDIAL INVESTIGATION AT KOTZEBUE LRRS

Metals	Site Designation											Evaluation Criteria		
	SS13 (AOC1)	SS15 (AOC4)	SS16 (AOC6)	AOC7	AOC8	AOC10	SS18 (AOC11)	SS02	SS07	SS08	Background	Practical Quantitation Limit	RCRA Toxicity Characteristic (mg/L)	3x Mean Background (mg/kg)
Aluminum	12,000	7,100	15,000	9,700	10,000	6,900	7,100	8,200	24,000	8,800	35,000	3	--	54,000
Antimony	4**B**	ND	ND	ND	7**B**	40	ND	ND	ND	ND	ND	10	--	85
Arsenic	9**B**	8**B**	6**B**	5**B**	10	90	7	7**B**	10**B**	10	800[a]	10	5.0	80
Barium	150	130	260	170	140	770	94	110	300	130	540	1	100	790
Beryllium	0.2	0.1	0.3	0.2	0.2	0.1**B**	ND	0.1	0.5	0.2	1.0	0.1	--	1.5
Cadmium	ND	ND	ND	ND	ND	30	ND	ND	ND	ND	ND	2	1.0	16
Calcium	30,000	39,000	34,000	52,000	76,000	24,000	58,000	29,000	5,400	38,000	23,000	7	--	36,200
Chromium	22	15	26	26	26	130	16	16	38	18	63	0.6	5.0	102
Cobalt	8	8	12	8	8	25	7	7	19	8	22	1	--	37
Copper	14	12	22	13	14	3,100	11	9.3	33	17	90	0.2	--	73
Iron	19,000	15,000	27,000	16,000	18,000	100,000	14,000	15,000	40,000	16,000	57,000	2	--	88,000
Lead	16	8.1	15	46	11	1,300	4.7	31	33	13	20	0.4	5.0	33
Magnesium	12,000	9,600	12,000	13,000	16,000	4,800	16,000	9,800	9,800	11,000	14,000	4	--	27,375
Manganese	330	320	500	300	340	600	290	300	380	300	660	1	--	1,298
Mercury	0.04	0.03	0.02**B**	0.11	0.01**B**	4.5	0.02	0.05	0.06	0.02B	0.2	0.03	0.2	0.22
Molybdenum	ND	ND	ND	ND	ND	8.7	ND	0.3**B**	ND	ND	1.0**B**	0.7	--	5.9
Nickel	37	31	40	36	42	83	37	26	51	38	70	2	--	127
Potassium	750	300	1,400	660	360	700	300	410	2,000	560	3,100	50	--	4,945
Selenium	6**B**	5**B**	9**B**	9**B**	9**B**	ND	10	6**B**	ND	7.0**B**	10**B**	10	1.0	94
Silver	ND	ND	0.4**B**	0.4**B**	ND	38	ND	0.1**B**	0.7**B**	0.2**B**	0.9	0.4	5.0	4.3
Sodium	310	180	200	200	250	5,800	130	190	190	190	370	20	--	765
Thallium	11	9	14	12	12	55	9	9	19	11	30	4	--	63
Vanadium	39	31	38	31	35	14	25	30	53	29	81	0.4	--	135
Zinc	62	40	71	36	39	12,000	28	65	1,200	140	150	0.8	--	257

[a] Background Sample SB1-10.5 was considered an outlier and not included in the mean background calculation.

Shading: Regulatory criteria are identified as applicable to detected compounds. If a regulatory criteria is exceeded, the associated compound are identified by shading.

ND = Compound non-detect at practical quantitation limit.

Data Qualifiers: B indicates data qualifier as applied by the laboratory and defined in Section 4.5.

TABLE 4-16. SUMMARY OF MAXIMUM GASOLINE, DIESEL, AND RESIDUAL RANGE ORGANICS CONCENTRATIONS DETECTED IN SOIL AND SEDIMENT SAMPLES COLLECTED DURING 1994 REMEDIAL INVESTIGATION AT KOTZEBUE LRRS				
Sample Designation	Range of Sample Depths (ft-below ground surface)	Total Gasoline Range Organics (mg/kg)	Total Diesel Range Organics (mg/kg)	Residual Range Organics (mg/kg)
SS13 (AOC1)	0.75-4.0	--	5,100	650
AOC2	1.5-3.5	--	5,100	--
SS14 (AOC3)	1.5-3.0	4,700	10,000	--
SS15 (AOC4)	1.0-7.0	950	10,000	7,900
AOC5	0.5-3.5	--	23,000	--
SS16 (AOC6)	1.0-3.0	--	25,000	1,300
AOC7	1.0	--	130	--
AOC8	1.0-3.5	120	3,500	--
ST04 (AOC9)	1.5-2.0	--	2,900	--
AOC10	--	--	8,600	8,900
SS18 (AOC11)	0.5-2.0	2,100	67,000	--
SS19 (AOC12)	0.5	--	27,000	--
SS02	0.5	--	2,400	31,000
ST05	0.5-13.0	--	18,000	36
SS07	0.5	--	440	2,400
SS08	1.0-1.5	--	33,000	290
SS11	0.5-1.0	--	710	--
SS12	0.5-7.8	--	53,000	--
Background	0.5-11.0	--	3,800	1,100
Practical Quantitation Limit	--	6	3	3
RCRA Toxicity Characteristic (mg/L)	--	--	--	--
ADEC Target Level for Soils (mg/kg)	--	--	1,000	--

Shading: Regulatory criteria are identified as applicable to detected compounds. If a regulatory criteria is exceeded, the criteria and associated compound are identified by shading.

-- = Not Analyzed.

TABLE 4-17. SUMMARY OF MAXIMUM VOLATILE ORGANIC COMPOUND CONCENTRATIONS DETECTED IN GROUNDWATER AND SURFACE WATER SAMPLES COLLECTED DURING 1994 REMEDIAL INVESTIGATION AT KOTZEBUE LRRS

Site Designation		Maximum Detected Volatile Organic Compounds (μg/L)										Total BETX (μg/L)
		Methylene Chloride	Acetone	Carbon Disulfide	Chloroform	2-Butanone	Trichloro-ethene	Benzene	Toluene	Ethyl-benzene	Total Xylenes	
SS13 (AOC1) (Surface water)		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SS16 (AOC6) (Surface water)		3.0B	7.0J	ND	ND	ND	ND	ND	ND	ND	ND	ND
SS02 (Surface water)		ND	ND	ND	1.0	ND	ND	ND	ND	ND	ND	ND
SS02 (Groundwater)		ND	ND	ND	ND	ND	2.0	ND	ND	ND	4.0	4.0
ST05 (Seawater)		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ST05 (Groundwater)		ND	8.0J	1.0J	ND	7.0	2.0	9.0J	43	80	430	562
SS07 (Surface water)		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SS11 (Surface water)		ND	5.0J	ND	ND	ND	ND	ND	ND	ND	ND	ND
SS12 (Surface water)		ND	22	ND	ND	2.0	ND	ND	1.0J	ND	ND	1.0
Background (Surface water)		ND	ND	ND	ND	ND	ND	ND	0.5JQ	ND	ND	0.5
Background (Groundwater)		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Practical Quantitation Limit		1	9	2	1	2	1	2	2	1	2	--
RCRA Toxicity Characteristic (μg/L)		--	--	--	6,000	--	500	500	--	--	--	--
Alaska Drinking Water Standards (μg/L)		--	--	--	--	--	5	5	1,000	700	10,000	--
Alaska Water Quality Standards (TAH Criterion) (μg/L)		--	--	--	--	--	--	--	--	--	--	10
Federal Water Quality Criteria (State's Compliance) (μg/L)	Freshwater Maximum	--	--	--	--	--	--	--	--	--	--	--
	Saltwater Maximum	--	--	--	--	--	--	--	--	--	--	--
	Human Health for Consumption of Water and Organisms[a]	--	--	--	57	--	27	12	6,800	3,100	--	--

[a] Risk for carcinogens 10^{-5}, State of Alaska.
-- = Not Applicable.
BETX = Benzene, ethylbenzene, toluene, and total xylenes.
ND = Compound non-detected at Practical Quantitation Limit.

Data Qualifiers: J, B, Q indicate data qualifiers as applied by the laboratory and defined in Section 4.5.

Shading: Regulatory criteria are identified as applicable to detected compounds. If a regulatory criteria is exceeded, the criteria and associated compound are identified by shading.

TABLE 4-18. SUMMARY OF MAXIMUM SEMIVOLATILE ORGANIC COMPOUND CONCENTRATIONS DETECTED IN GROUNDWATER AND SURFACE WATER SAMPLES COLLECTED DURING 1994 REMEDIAL INVESTIGATION AT KOTZEBUE LRRS

Sample Designation		Maximum Detected Semivolatile Organic Compounds (µg/L)														Total PAHs [µg/L]
		Phenol	1,3-Dichlorobenzene	Isophorone	4-Methylphenol	Benzoic Acid	Naphthalene	2-Methylnaphthalene	Acenaphthylene	Acenaphthene	Dibenzofuran	Fluorene	Phenanthrene	bis(2-Ethylhexyl) phthalate	Di-n-Octylphthalate	
SS16 (AOC6) (Surface water)		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0J	ND	1.0
SS02 (Surface water)		ND	1.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0
SS02 (Groundwater)		ND	3.0	ND	ND	ND	ND	2.0Q	ND	ND	ND	2.0	1.0J	7.0	2.0	17
ST05 (Sea water)		ND	1.0J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0
ST05 (Groundwater)		3.0Q	1.0	ND	9.0JQ	54Q	230	190	2.0JQ	2.0Q	1.0JQ	4.0	2.0J	1.0J	3.0	505
SS07 (Surface water)		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SS11 (Surface water)		ND	1.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0
SS12 (Surface water)		ND	1.0	1.0J	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0J	ND	3.0
Background (Surface water)		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Background (Groundwater)		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Practical Quantitation Range		3	1	2	2	10	1	2	2	2	2	2	2	2	2	--
RCRA Toxicity Characteristic (µg/L)		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Alaska Drinking Water Standards (µg/L)		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Alaska Water Quality Standards (TAqH Criterion) (µg/L)		--	--	--	--	--	--	--	--	--	--	--	--	--	--	15
Federal Water Quality Criteria (State's Compliance (µg/L)	Freshwater Maximum	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Saltwater Maximum	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Human Health for Consumption of Water and Organisms[a]	210,000	4,000	840	--	--	--	--	--	--	--	13,000	--	18	--	--

[a] Risk for carcinogens 10^{-5}, State of Alaska.
PAH = Polyaromatic hydrocarbons are summed to evaluate the Alaska total aqueous hydrocarbons (TAqH) Water Quality Standard.
ND = Compound non-detected at Practical Quantitation Limit.

Data Qualifiers: J and Q indicate data qualifiers as applied by the laboratory and defined in Section 4.5.
-- = Not Applicable.
Shading: Regulatory criteria are identified as applicable to detected compounds. If a regulatory criteria is exceeded, the criteria and associated compound are identified by shading.

TABLE 4-19. SUMMARY OF MAXIMUM PESTICIDE/PCBs CONCENTRATIONS DETECTED IN GROUNDWATER AND SURFACE WATER SAMPLES COLLECTED DURING 1994 REMEDIAL INVESTIGATION AT KOTZEBUE LRRS

Site Designation		Maximum Detected Pesticides/PCBs Compounds (μg/L)										
		Alpha-BHC	Beta-BHC	Delta-BHC	Heptachlor	Aldrin	Heptachlor Epoxide	Dieldrin	Ensosulfan Sulfate	4,4'-DDE	4,4'-DDD	4,4'-DDT
SS16 (AOC6) (Surface water)		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SS02 (Surface water)		ND	ND	ND	ND	ND	ND	ND	ND	0.065	0.045	0.039
SS02 (Groundwater)		ND	ND	ND	ND	ND	ND	ND	ND	0.074	0.057	0.40
SS07 (Surface water)		ND	ND	ND	ND	ND	0.12X	ND	ND	ND	ND	ND
SS11 (Surface water)		ND	0.07X	0.06X	ND	ND	0.02X	ND	ND	ND	0.052	ND
SS12 (Surface water)		0.13X	0.19X	ND	0.05X	0.05X	0.3X	0.03X	0.07X	ND	0.075	0.094X
Background (Surface water)		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Background (Groundwater)		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Practical Quantitation Limit		0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.01	0.029	0.017	0.031
RCRA Toxicity Characteristic (μg/L)		--	--	--	8	--	8	--	--	--	--	--
Alaska Drinking Water Standards (μg/L)		--	--	--	0.4	--	0.2	5	--	1,000	700	10,000
Alaska Water Quality Standards (μg/L)		--	--	--	--	--	--	--	--	--	--	--
Federal Water Quality Criteria (State's Compliance) (μg/L)	Freshwater Maximum	--	--	--	0.52	3	0.52	2.5	--	--	--	1.1
	Saltwater Maximum	--	--	--	0.053	1.3	0.053	0.71	--	--	--	0.13
	Human Health for Consumption of Water and Organisms[a]	0.039	0.14	--	0.0021	0.0013	0.0010	0.0014	9.3	0.0059	0.0083	0.0059

[a] Risk for carcinogens 10^{-5}, State of Alaska.

-- = Not Applicable.

ND = Compound non-detected at Practical Quantitation Limit.

Data Qualifiers: X indicates data qualifiers as applied by the laboratory and defined in Section 4.5.

Shading: Regulatory criteria are identified as applicable to detected compounds. If a regulatory criteria is exceeded, the criteria and associated compound are identified by shading.

TABLE 4-20. SUMMARY OF MAXIMUM METALS CONCENTRATIONS DETECTED IN GROUNDWATER AND SURFACE WATER SAMPLES COLLECTED DURING 1994 REMEDIAL INVESTIGATION AT KOTZEBUE LRRS
(Page 1 of 2)

Metals	Sample Designation								Evaluation Criteria										
	AOC6 (Surface Water)	SS02 (Surface Water)		SS02 (Groundwater)		SS07 (Surface Water)		Practical Quantitation Limit	RCRA Toxicity Characteristic (mg/L)	Alaska Drinking Water Standards		Federal Water Quality Criteria (State's Compliance) (mg/L)			3X Mean Background Concentration (mg/L)				
															Surface Water		Groundwater		
	Total Metals	Total Metals	Dissolved Metals	Total Metals	Dissolved Metals	Total Metals	Dissolved Metals			Primary Standards (mg/L)	Secondary Standards (mg/L)	Freshwater Maximum	Saltwater Maximum	Human Health for Consumption of Water and Organisms[a]	Total	Dissolved	Total	Dissolved	
Aluminum	0.01B	ND	ND	2.2	0.04	0.08	0.05	0.03	--	--	0.2	--	--	--	0.519	0.18	8.4	0.045	
Antimony	ND	ND	ND	ND	ND	ND	ND	0.1	--	0.006	--	--	--	--	0.15	0.15	0.15	0.15	
Arsenic	ND	ND	ND	ND	ND	ND	ND	0.1	5.0	0.05	--	0.360	0.069	0.00018	0.15	0.15	0.15	0.15	
Barium	0.18	0.11	0.11	0.22	0.14	0.05	0.04	0.01	100.0	2.0	--	--	--	--	0.099	0.099	0.57	0.33	
Beryllium	ND	ND	ND	ND	ND	ND	ND	0.001	--	0.004	--	--	--	--	0.0015	0.0015	0.0015	0.0015	
Cadmium	ND	ND	ND	ND	ND	ND	ND	0.02	1.0	0.005	--	0.0039	0.043	--	0.03	0.045	0.03	0.03	
Calcium	77	66	67	65	59	13	13	0.07	--	--	--	--	--	--	39.23	48.6	420	420	
Chromium	ND	ND	ND	0.01	ND	ND	ND	0.006	5.0	0.100	--	1.7	--	--	0.008	0.009	0.033	0.009	
Cobalt	ND	ND	ND	0.005B	ND	ND	ND	0.01	--	--	--	--	--	--	0.015	0.015	0.03	0.015	
Copper	0.002B	0.002B	0.002B	0.015	0.004	0.005	0.004	0.002	--	1.3[b]	1.0	0.018	0.0029	--	0.014	0.011	0.06	0.015	
Iron	0.96	0.1	ND	8.1	1.1	1.8	1.4	0.02	--	--	0.3	--	--	--	3.26	1.75	21.9	0.03	
Lead	0.002B	0.002B	0.003B	0.008	0.004	ND	ND	0.04	5.0	0.015[b]	--	0.082	0.220	--	0.006	0.008	0.018	0.006	
Magnesium	10	21	22	18	17	3.5	3.5	0.04	--	--	--	--	--	--	10.65	12.20	96	90	
Manganese	0.27	0.02	0.02	0.36	0.29	0.03	0.02	0.01	--	--	0.05	--	--	--	0.129	0.08	0.75	0.21	
Mercury	ND	0.00002B	ND	0.00007B	ND	ND	ND	0.00001	0.2	0.002	--	0.0024	0.0021	0.14	0.00036	0.00009	0.00012	0.00009	
Molybdenum	ND	ND	ND	0.003B	0.003B	ND	ND	0.007	--	--	--	--	--	--	0.011	0.009	0.011	0.011	
Nickel	0.01B	ND	ND	0.01B	ND	ND	ND	0.02	--	0.1	--	1.4	0.075	610	0.03	0.045	0.06	0.03	
Potassium	1.2	4.6	4.8	9.8	10	0.7	0.5B	0.5	--	--	--	--	--	--	2.18	2.20	10.8	9.9	
Selenium	ND	ND	ND	ND	ND	ND	ND	0.1	1.0	0.05	--	0.020	0.300	--	0.15	0.15	0.15	0.15	
Silver	ND	ND	ND	ND	ND	ND	ND	0.004	5.0	--	0.1	0.0041	0.0023	--	0.006	0.0045	0.006	0.006	
Sodium	6.2	9.2	9.1	120	130	2.7	2.9	0.2	--	--	--	--	--	--	12.15	11.10	123	123	
Thallium	ND	ND	ND	0.03B	0.02B	ND	ND	0.04	--	0.002	--	--	--	1.7	0.06	0.045	0.06	0.06	
Vanadium	ND	ND	ND	0.011	ND	ND	ND	0.004	--	--	--	--	--	--	0.006	0.004	0.033	0.006	
Zinc	0.025	0.006B	0.005B	0.021	0.003B	0.007B	0.005B	0.008	--	--	5.0	0.120	0.095	--	0.031	0.014	0.072	0.012	

TABLE 4-20. SUMMARY OF MAXIMUM METALS CONCENTRATIONS DETECTED IN GROUNDWATER AND SURFACE WATER SAMPLES COLLECTED DURING 1994 REMEDIAL INVESTIGATION AT KOTZEBUE LRRS
(Page 2 of 2)

Metals	Sample Designation							Evaluation Criteria									
	SS12 (Surface Water)	ST05 (Groundwater)	Background (Surface Water)		Background (Groundwater)				Alaska Drinking Water Standards		Federal Water Quality Criteria (State's Compliance) (mg/L)			3x Mean Background Concentration (mg/L)			
														Surface Water		Groundwater	
	Total Metals (6010)	Total Metals (6010)	Total Metals	Dissolved Metals	Total Metals	Dissolved Metals	Practical Quantitation Limit	RCRA Toxicity Characteristic (mg/L)	Primary Standards (mg/L)	Secondary Standards (mg/L)	Freshwater Maximum	Saltwater Maximum	Human Health for Consumption of Water and Organisms[a]	Total	Dissolved	Total	Dissolved
Aluminum	--	--	0.38	0.12	2.8	ND	0.03	--	--	0.2	--	--	--	0.519	0.18	8.4	0.045
Antimony	--	--	ND	ND	ND	ND	0.1	--	0.006	--	--	--	--	0.15	0.15	0.15	0.15
Arsenic	--	--	ND	ND	ND	ND	0.1	5.0	0.05	--	0.360	0.069	0.00018	0.15	0.15	0.15	0.15
Barium	--	--	0.05	0.05	0.19	0.11	0.01	100.0	2.0	--	--	--	--	0.099	0.099	0.57	0.33
Beryllium	--	--	ND	ND	ND	ND	0.001	--	0.004	--	--	--	--	0.0015	0.0015	0.0015	0.0015
Cadmium	--	--	ND	ND	ND	ND	0.02	1.0	0.005	--	0.0039	0.043	--	0.03	0.045	0.03	0.03
Calcium	120	130	38	38	140	140	0.07	--	--	--	--	--	--	39.23	48.6	420	420
Chromium	--	--	0.002B	ND	0.011	ND	0.006	5.0	0.100	--	1.7	--	--	0.008	0.009	0.033	0.009
Cobalt	--	--	ND	ND	0.01B	ND	0.01	--	--	--	--	--	--	0.015	0.015	0.03	0.015
Copper	--	--	0.007	0.005	0.02	0.005	0.002	--	1.3[b]	1.0	0.018	0.0029	--	0.014	0.011	0.06	0.015
Iron	4.1	41	2.2	0.91	7.3	ND	0.02	--	--	0.3	--	--	--	3.26	1.75	21.9	0.03
Lead	--	--	0.002B	0.004B	0.006	ND	0.04	5.0	0.015[b]	--	0.082	0.220	--	0.006	0.008	0.018	0.006
Magnesium	41	54.9	8.2	8.2	32	30	0.04	--	--	--	--	--	--	10.65	12.20	96	90
Manganese	--	--	0.06	0.05	0.25	0.07	0.01	--	--	0.05	--	--	--	0.129	0.08	0.75	0.21
Mercury	--	--	0.00003B	ND	0.00004B	ND	0.00001	0.2	0.002	--	0.0024	0.0021	0.14	0.00036	0.00009	0.00012	0.00009
Molybdenum	--	--	ND	ND	ND	ND	0.007	--	--	--	--	--	--	0.011	0.009	0.011	0.011
Nickel	--	--	ND	ND	0.02	ND	0.02	--	0.1	--	1.4	0.075	610	0.03	0.045	0.06	0.03
Potassium	0.7	21	1.3	1.1	3.6	3.3	0.5	--	--	--	--	--	--	2.18	2.20	10.8	9.9
Selenium	--	--	ND	ND	ND	ND	0.1	1.0	0.05	--	0.020	0.300	--	0.15	0.15	0.15	0.15
Silver	--	--	ND	ND	ND	ND	0.004	5.0	--	0.1	0.0041	0.0023	--	0.006	0.0045	0.006	0.006
Sodium	24	562	5.3	5.3	41	41	0.2	--	--	--	--	--	--	12.15	11.10	123	123
Thallium	--	--	ND	ND	ND	ND	0.04	--	0.002	--	--	--	1.7	0.06	0.045	0.06	0.06
Vanadium	--	--	0.002B	0.001B	0.011	0.002B	0.004	--	--	--	--	--	--	0.006	0.004	0.033	0.006
Zinc	--	--	0.013	0.006B	0.024	0.004B	0.008	--	--	5.0	0.120	0.095	--	0.031	0.014	0.072	0.012

[a] Risk for carcinogens 10^{-5}, State of Alaska.
[b] Federal Drinking Water Standard Action Level.
ND = Compound non-detected at Practical Quantitation Limit.
-- = Not Applicable.
Data Qualifiers: B indicates data qualifier as applied by the laboratory and defined in Section 4.5.
Shading: Regulatory criteria are identified as applicable to detected compounds. If a regulatory criteria is exceeded, the criteria and associated compound are identified by shading.

TABLE 4-21. SUMMARY OF DIESEL RANGE ORGANICS CONCENTRATIONS DETECTED IN GROUNDWATER AND SURFACE WATER SAMPLES COLLECTED DURING 1994 REMEDIAL INVESTIGATION AT KOTZEBUE LRRS

Site Designation		Total Diesel Range Hydrocarbons
SS13 (AOC1) (Surface water)		2.0
SS16 (AOC6) (Surface water)		0.11
SS02 (Surface water)		ND
SS02 (Groundwater)		5.5
ST05 (Sea water)		ND
ST05 (Groundwater)		34
SS07 (Surface water)		ND
SS11 (Surface water)		0.81
SS12 (Surface water)		8.8
Background (Surface water)		ND
Background (Groundwater)		ND
Practical Quantitation Limit		0.11
RCRA Toxicity Characteristic (mg/L)		--
Alaska Drinking Water Standard (mg/L)		--
Alaska Water Quality Standard (mg/L)		0.015
Federal Water Quality Criteria (State's Compliance) (mg/L)	Freshwater Maximum	--
	Saltwater Maximum	--
	Human Health for Consumption of Water and Organisms	--

ND = Compound non-detected at Practical Quantitation Limit.

-- = Not Applicable.

Shading: Regulatory criteria are identified as applicable to detected compounds. If a regulatory criteria is exceeded, the criteria and associated compound are identified by shading.

The contaminant analysis summary tables (Tables 4-12 through 4-21) include state and federal regulatory criteria pertinent to Kotzebue LRRS for the evaluation of: 1) constituents classified as a hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA); and 2) compliance with established state and federal health-based standards (see Section 4.2, Applicable or Relevant and Appropriate Requirements).

4.5.1 Evaluation Criteria for Surface Water and Groundwater

The Alaska Department of Environmental Conservation (ADEC) considers sites at Kotzebue LRRS regulated under Water Quality Standards Regulation (18 AAC 70), based on the presence of petroleum hydrocarbons at the site, and the potential for petroleum hydrocarbon migration to surface water and groundwater adjacent to the facility. Groundwater and surface water analytical results were evaluated with respect to established state standards by comparing sample analytical results to applicable ADEC Water Quality Standard Regulations (18 AAC 70; January 1995). ADEC Drinking Water Regulations (18 AAC 80, as amended through March 1993) were also evaluated as they may apply to ADEC Water Quality Standards for fresh water recreational use (18 AAC 70.020; January 1995).

In December 1991, the EPA published the "final toxics rule" which promulgated water quality criteria for 126 priority pollutants for states (including Alaska) that did not have U.S. EPA-approved water quality criteria (EPA 1992). The EPA establishment of numerical water quality for priority pollutants for the state of Alaska, including fresh- and saltwater maximum concentrations and human health criteria for the consumption of water and organisms. These criteria were evaluated for both surface water and groundwater analytical results presented in Tables 4-17 through 4-21. The EPA indicates the human health criteria shall be applied at the 10^{-5} risk level, consistent with state policy (EPA 1992).

Groundwater and surface water analytical results were evaluated for toxicity characteristics by comparing field sample analytical results to RCRA toxicity characteristics (TC) regulatory criteria (53 Federal Register 51444, December 21, 1988; and 40 CFR Part 261 Section 1.2 Appendix II).

4.5.2 Evaluation Criteria for Soil

The ADEC has established a soil target level for diesel range organics at 1,000 mg/kg to assist in the definition of the lateral and vertical extent of petroleum hydrocarbon contamination in soils at Kotzebue LRRS. Soils are evaluated based on the ADEC soil target level (1,000 mg/kg) and for toxicity characteristics by comparing field sample analytical results to RCRA toxicity characteristics regulatory

criteria (53 Federal Register 51444, December 21, 1988; and 40 CFR Part 261 Section 1.2 Appendix II). PCB (Aroclor 1254 and 1260) were detected in a limited number of soil samples during the 1994 RI, and are evaluated in Tables 4-12 through 4-16 based on a 10 mg/kg target cleanup level established from EPA Region 10 guidance (see Section 4.2, Applicable or Relevant and Appropriate Requirements).

4.6 FIELD ACTIVITY RESULTS

This section discusses the results of field related activities conducted in support of site characterization, further definition of ARARs, baseline risk assessment, and the refinement of the site conceptual model at Kotzebue LRRS.

4.6.1 Static Water Level Measurement

Three independent series of static water level measurements were collected during the 1994 field investigation (Table 4-22). Static water level measurements were collected to coincide with Kotzebue Sound high and low tide cycles to evaluate the degree of influence tides may have on the near-beach aquifer. Based on an initial evaluation of static water levels measured during high tide (20 July 1994) and low tide (24 July 1994) cycles, it was discovered that a number of forebeach monitoring wells (e.g., ST05-MW6, MW9, SS02-MW1, MW2, and MW3, and background-MW1) revealed higher static water levels during the low tide cycle (see Table 4-22). However, it was noted that strong offshore winds were prevalent during the 20 July 1994 low tide water level measurement event, which may have effected near-beach water levels. The average wind speed on 20 July 1994 was 14 mph with a maximum of 29 mph from the west.

On 25 July 1994, a second round of low tide water level measurements were taken to evaluate low tide conditions when offshore winds were not prevalent. Results of the 25 July 1994 groundwater level measurements revealed groundwater elevations in all monitoring wells below those measured during high tide (see Table 4-22). On 25 July 1994, the average wind speed was 11 mph (maximum at 29 mph) from the southeast.

Results of the static water level measurements collected at Kotzebue LRRS indicate that Kotzebue Sound tidal cycles have a measurable influence on the near-beach aquifer system. However, other factors such

TABLE 4-22. SUMMARY OF GROUNDWATER LEVEL MEASUREMENTS TAKEN DURING 1994 REMEDIAL INVESTIGATION FOR KOTZEBUE LRRS, JULY 1994

Well Designation	Well Elevation	Well Location		Measured 7/20/94[a]			Measured 7/24/94[b]			Measured 7/25/94[c]		
		Northing	Easting	Time	Water Level	Water Elevation	Time	Water Level	Water Elevation	Time	Water Level	Water Elevation
ST05-MW1	9.21	4693466.319	1553804.639	1248:30	7.01	2.20	0929:30	6.33	2.88	1625:45	6.53	2.68
ST05-MW2	9.13	4694117.471	1553343.308	1258:00	7.31	1.82	0934:30	7.03	2.10	1627:45	7.04	2.09
ST05-MW3	8.68	4694370.688	1553198.730	1303:00	6.98	1.70	0939:30	6.80	1.88	1631:00	6.82	1.86
ST05-MW4	8.26	4693921.745	1553614.676	1250:30	6.47	1.79	0933:00	6.02	2.24	1634:00	6.13	2.13
ST05-MW5	6.60	4693867.191	1553544.810	1253:00	4.87	1.73	0932:00	4.67	1.93	1627:00	4.74	1.86
ST05-MW6	5.02	4693796.036	1553449.952	1254:30	3.00	2.02	0931:00	3.42	1.60	1624:00	3.88	1.14
ST05-MW7	6.61	4694278.402	1553342.670	1300:00	4.77	1.84	0935:30	4.37	2.24	1628:30	4.42	2.19
ST05-MW8	5.03	4694063.073	1553275.224	1256:30	3.90	1.13	0936:00	3.49	1.54	1629:15	3.88	1.15
ST05-MW9	5.70	4694199.692	1553183.028	1301:30	3.59	2.11	0938:00	4.18	1.52	1630:30	4.52	1.18
SS02-MW1	8.07	4695341.157	1552522.226	1309:30	6.44	1.63	0943:00	6.63	1.44	1633:30	6.74	1.33
SS02-MW2	5.13	4694649.167	1552861.320	1308:00	3.02	2.11	0941:30	3.67	1.46	1632:30	4.10	1.03
SS02-MW3	4.39	4694402.365	1553025.753	1306:30	2.30	2.09	0940:30	2.89	1.50	1631:30	3.39	1.00
BKG-MW1	8.13	4695994.021	1552126.974	1311:00	6.61	1.52	0944:00	6.96	1.17	1634:30	7.34	0.79

[a] Measured on storm event/low tide [-0.4 feet-mean lower low water (ft-M.L.L.W.)].
[b] Measured on high tide event (+3.1 ft-M.L.L.W.).
[c] Measured on low tide event (-0.4 ft-M.L.L.W.).

Well elevation = top of well casing in ft (relative).
Well location = state-plane coordinate system (NAD'83; AK7).
Water level = feet below top of well casing (ft-TOC).
Water elevation = feet (relative to COE, BAT).

as storm events can more significantly influence the hydrology of the near-beach aquifer system than tidal variation.

4.6.1.1 Hydraulic Gradients and Groundwater Flow Direction. In general, groundwater flows toward the southwest with the flowlines perpendicular to Kotzebue Sound and groundwater discharging to the Sound as would be expected. Hydraulic gradients calculated at high tide on 24 July 1994 and low tide on 25 July 1994 fluctuate from 0.0032 feet per feet to 0.0049 feet per feet, respectively.

4.6.2 Slug Test Results

Slug tests were conducted in three monitoring wells (ST05-MW4, MW5, MW6) installed in the vicinity of the ST05-Beach Tanks Site to evaluate horizontal hydraulic conductivity in the near-beach aquifer at Kotzebue LRRS (see Figure 4-2). The maximum drawdown observed during testing included 0.87 feet in Well ST05-MW4, 1.15 feet in Well ST05-MW5, and 1.22 feet in Well ST05-MW6. Complete static water level recovery was observed in well ST05-MW4 (back-beach) within 10 seconds, in Well ST05-MW5 (mid-beach) within 31 seconds, and in Well ST05-MW6 (fore-beach) within 57 seconds. The slug test data was analyzed using Geraghty Miller's Aquifer Test Design and Analysis computer software (AQTESOLV^{TM}) version 1.1, employing the Bouwer-Rice method for unconfined aquifers to provide estimates of hydraulic conductivity. Figure 4-8 provides rising-head slug test solutions for estimating hydraulic conductivity in the near-beach aquifer at Site ST05-Beach Tanks. Slug test results, test description, and statistical data evaluation as generated by AQTESOLV^{TM} is provided in Appendix D.

In Figure 4-8 test input data are identified which were used to define Bouwer-Rice method solutions for estimating hydraulic conductivity. Test input parameters are defined below:

HO	Initial drawdown observed due to instantaneous removal of slug from well
rc	Radius of well casing
rw	Radius of well (including filter pack)
L	Length of well screen
b	Saturated thickness of aquifer
H	Static height of water in well

AQTESOLV™ (Bouwer-Rice Method)

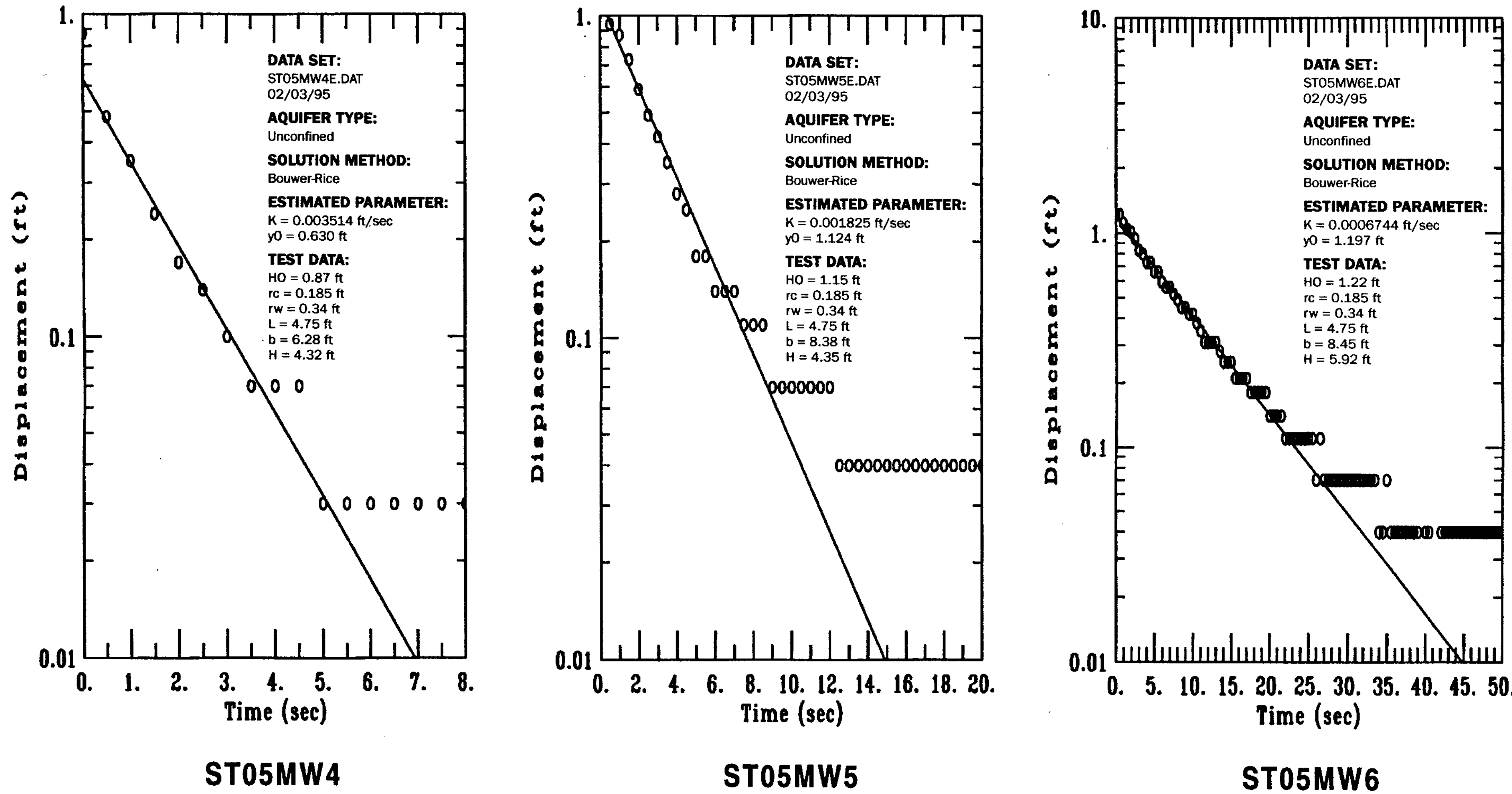

Figure 4-8. Rising-Head Slugtest Solutions for Estimating Hydraulic Conductivity in the Unconfined Near-beach Aquifer, 1994 Remedial Investigtaion, Kotzebue LRRS, Alaska.

The Bouwer-Rice method was developed for the rise or fall of the water level to be measured within the solid casing of the well. In this case the variable (rc) is equal to the radius of the casing. However, at Kotzebue LRRS, the rise of the water level was measured within the screen portion of the well which is surrounded by a filter pack. Therefore, (rc) must be modified (Freeze and Cherry 1979). An equivalent value for (rc) was calculated which includes the free water effect of the filter pack as follows:

$$rc = [(rc^2+n(rw^2-rc^2)]^{1/2} = \text{"equivalent radius of the casing"}$$

where:

n	=	Porosity of the gravel pack
rw	=	Radius of the gravel pack

Slug test results using the Bouwer-Rice method to estimate horizontal conductivity in the near-beach aquifer at Kotzebue LRRS are as follows:

Slug Test Results		
Monitoring Well	Sample Date	Horizontal Hydraulic Conductivity (cm/sec)
ST05-MW4 (Back-Beach)	27 July 1994	1.78×10^{-3}
ST05-MW5 (Mid-beach)	24 July 1994	9.25×10^{-4}
ST05-MW6 (Fore-beach)	24 July 1994	3.42×10^{-4}

4.6.2.1 Groundwater Velocities. The rate of groundwater flow (i.e., the average linear velocity) in porous media can be calculated by the following equation (Freeze and Cherry 1979):

$$V = (K \times I)/n$$

where:

V	=	Average linear pore water velocity (feet/day)
K	=	Hydraulic conductivity (feet/day)

I	=	Hydraulic gradient (dimensionless)
n	=	Porosity (dimensionless)

The average hydraulic conductivity from wells ST05-MW4, MW5, and MW6 based upon slug test results is 2.88 feet per day. A porosity of 0.25 is a reasonable estimate for sandy gravels and gravelly sands (Freeze and Cherry 1979). The hydraulic gradients for these wells has been previously discussed in Section 4.6.1.1 and they vary from 0.0032 feet per feet to 0.0049 feet per feet at high and low tide, respectively. Groundwater flow based upon these measurements varies from 14 feet per year at high tide to 20 feet per year at high tide. Therefore, a reasonable calculated estimate of groundwater flow in the vicinity of Site ST05 is about 17 feet per year.

4.6.2.2 Discussion. Estimates of hydraulic conductivity in wells ST05-MW4 and ST05-MW5 are typical of clean sands. The hydraulic conductivity calculated for Monitoring Well ST05-MW6 is slightly lower than Wells MW4 and MW5, typical of silty sands (Freeze and Cherry 1979). A review of monitoring well boring logs ST05-MW4/SB12, ST05-MW5/SB13, and ST05-MW6/SB14 indicates screen interval lithologies (i.e., sandy Gravel/gravelly Sand with silt) consistent with slug test estimates of hydraulic conductivity (see Appendix A).

Permeability (vertical hydraulic conductivity) was estimated in the fore-beach, mid-beach, and back-beach areas at Kotzebue LRRS through geotechnical sampling and permeability laboratory testing (see Section 4.4.7, Geotechnical Assessment.

The geotechnical samples collected for permeability lab testing from the beach area at Kotzebue LRRS were taken from the vadose zone just above the groundwater surface, and from the saturated zone just below the groundwater surface. Soil permeability test results indicate a decrease approximately one order of magnitude in hydraulic conductivity when compared to the slug test data results.

Soil Permeability Test Results		
Geotechnical Sample	Sample Date	Vertical Hydraulic Conductivity (cm/sec)
SS02-GT10-B (Back-beach)	4 July 1994	2.82×10^{-4}
ST05-GT7-B (Mid-beach)	4 July 1994	2.36×10^{-4}
SS02-GT8-B (Fore-beach)	4 July 1994	8.39×10^{-5}

In layered geologic sequences it is common to observe vertical hydraulic conductivities several orders of magnitude lower than horizontal hydraulic conductivities because of the platy nature of silt and clay size particles. This type of phenomena is typical of anisotropic systems. The differences observed between horizontal and vertical hydraulic conductivities at Kotzebue LRRS are consistent with the beach sands and gravels which characterize the near-beach aquifer. A detailed review of geologic soil borings (e.g., ST05-SB13/MW5) indicates that distinct bedding does exist including fine sand and silt layers (micro bedding). Such bedding may affect vertical flow and is suspected to result in the slight anisotropic nature of the shallow near-beach aquifer. The permeability soil test results should be qualified by stating that it is extremely difficult to characterize the hydraulic conductivity of a stratified aquifer, or even a small portion of an aquifer, by means of laboratory measurements (McWhorter and Sunada 1977). This is due to the limitations inherent in the small sample size, the necessary repacking of the sample into the testing vessel, and the variability between vertical and horizontal hydraulic conductivities within the formation. The most reliable method for determining the hydraulic conductivity of an aquifer zone is actual field measurements obtained during slug and/or pumping tests.

4.6.3 Tidal Monitoring Results

The mean tidal range for Kotzebue Sound is 2.1 feet at the nearest location where tidal corrections have been established (Kiwalik, Kotzebue Sound); the diurnal tidal range at Kiwalik is 2.7 feet (NOAA 1990). Continuous tidal monitoring was conducted between 24 July and 26 July 1994 to evaluate diurnal tidal influences on the near-beach unconfined groundwater system at Kotzebue LRRS. The maximum tide cycle amplitude recorded at Kiwalik during tidal monitoring at Kotzebue LRRS was measured on 25 July 1994 between 9:14 am (higher-high water) and 3:35 pm (lower-low water) at 3.10 feet (NOAA 1994).

Three shallow monitoring wells installed at Site ST05 were selected to evaluate tidal influence on the near-beach groundwater system. These wells include ST05-MW4 (back-beach), ST05-MW5 (mid-beach), and ST05-MW6 (fore-beach) (see Figure 4-2). Figure 4-9 represents the response to Kotzebue Sound tidal fluctuations observed in Wells ST05-MW4, MW5, and MW6. The harmonic groundwater level changes observed in monitoring wells MW4, MW5, and MW6 are indicative of the diurnal fluctuation in Kotzebue Sound. The greatest amplitude of groundwater fluctuation was recorded in monitoring well MW6 at 0.24 feet. Groundwater fluctuation in monitoring wells MW5 and MW4 were recorded at a maximum amplitude of 0.17 feet in each well (see Figure 4-9).

The observed lag time between water level response in monitoring wells and the Kotzebue Sound cannot be quantified due to the lack of a common shoreline datum. However, the groundwater fluctuations observed in the monitoring wells do not appear to respond directly to the tidal cycles as demonstrated by the graphs presented in Figure 4-9. It has been shown that prevailing offshore winds can overcome the effects from tidal variation in the near-beach groundwater system, thus limiting the usefulness of data to quantify tidal response (see Section 4.6.1, Static Water Level Measurement).

4.6.3.1 Discussion. Tidal fluctuation in Kotzebue Sound clearly impacts the near-beach aquifer in the vicinity of Kotzebue LRRS. However, based upon the limited vertical extent of the water table aquifer and the observed tidal fluctuation in the monitoring wells it is unlikely that the tidal cycles have a significant effect on groundwater migration to the Sound. Observed changes in groundwater geochemistry at Site ST05 indicate that seawater is mixing with shallow groundwater along the upper beach face (see Section 4.6.6.2, Near-Beach Groundwater Flowpath). The mixing of seawater in the fore-beach area at Kotzebue LRRS is induced in part by tidal fluctuation in Kotzebue Sound.

4.6.4 Geotechnical Sample Results

All geotechnical samples were submitted for testing to EBA Engineering Inc., Anchorage Alaska. TOC soil samples were submitted to Analytical Resources Inc., (ARI) Seattle, WA, for analysis. Table 4-23 provides a summary of geotechnical and TOC soil sample results. A geotechnical data report prepared by EBA Engineering, Inc. is provided in Appendix E.

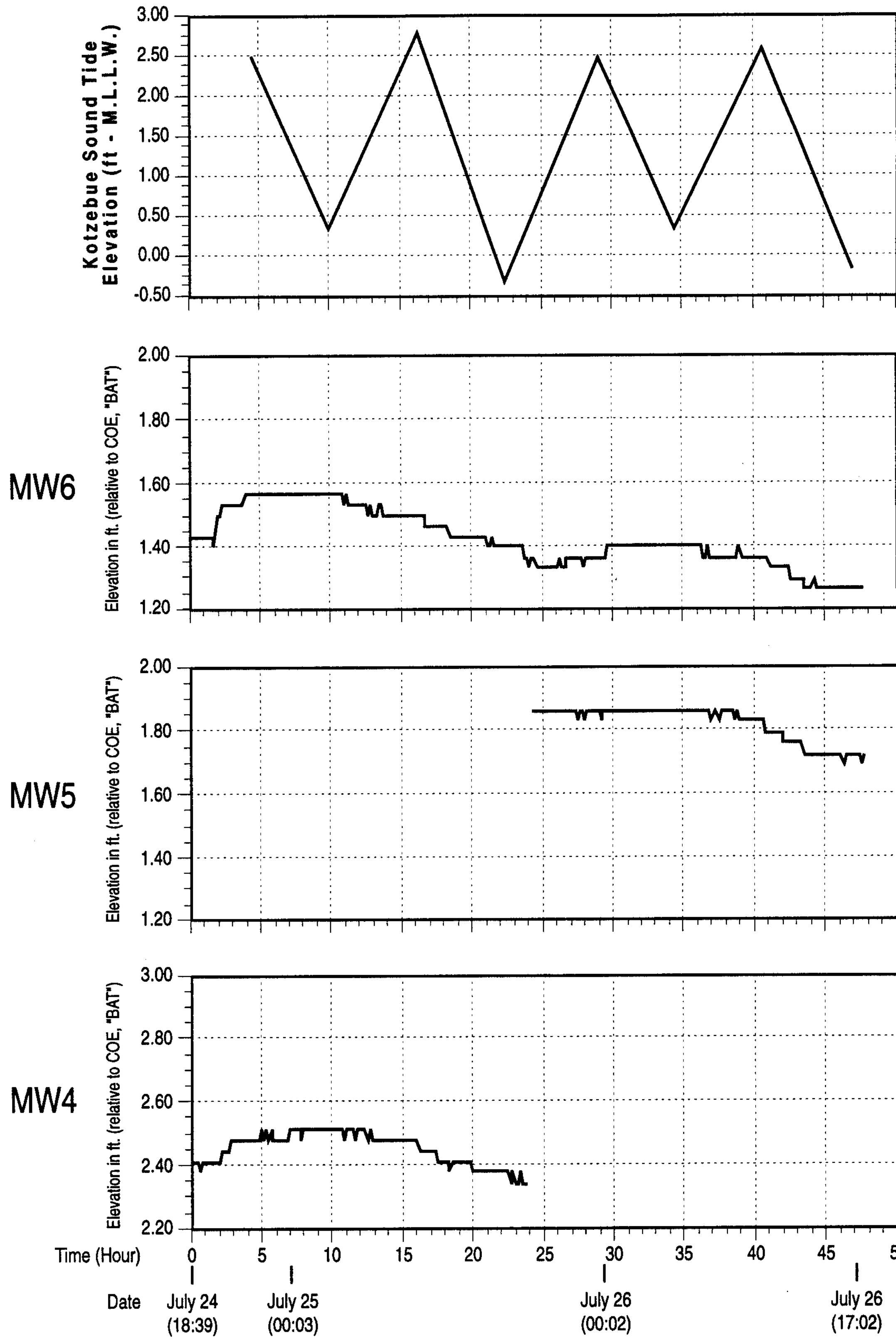

Figure 4-9. Tidal Influence Monitoring Records for Wells MW6, MW5 and MW4. Site ST05-Beach Tanks, 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

TABLE 4-23. SUMMARY OF GEOTECHNICAL TEST RESULTS FOR SELECTED SOIL SAMPLES DURING 1994 REMEDIAL INVESTIGATION, KOTZEBUE LRRS, ALASKA

Sample Identification	Sample Depth Interval (ft)		Moisture Content (%)	Bulk Density (pcf)	Dry Density (pcf)	Vertical Hydraulic Conductivity (cm/sec)	U.S.C.S.	Grain Size Distribution (%)			Common Name	Total Organic Carbon (mg/kg)
	Top	Bottom						Gravel (GR)	Sand (SA)	Silt-Clay (ML-CL)		
AOC8-GT1-T	0.25	2.5	49.5	105.6	70.6	2.17×10^{-6}	ML	0.0	3.4	96.6	Silt	79,200
AOC8-GT2-F	4.0	6.0	13.1	134.8	119.2	3.35×10^{-4}	GW	61.1	35.2	3.7	Sandy Gravel	12,600
AOC6-GT3-T	2.5	5.0	37.3	114.5	83.4	2.08×10^{-6}	ML	0.0	2.4	97.6	Silt	37,300
AOC6-GT4-F	4.5	6.5	34.0	116.9	87.2	7.27×10^{-6}	ML	0.0	3.2	96.8	Silt	17,400
AOC4-GT5-F	3.0	5.0	26.8	123.8	97.6	1.37×10^{-6}	ML	6.3	46.5	47.2	Sandy Silt	61,500
AOC7-GT6-T	1.0	3.0	40.9	112.4	79.8	4.99×10^{-6}	ML	0.0	1.7	98.3	Silt	30,500
ST05-GT7-B	4.0	7.0	11.6	138.3	124.0	2.36×10^{-4}	GM	46.9	37.7	15.4	Silty, Sandy Gravel	24,100
SS02-GT8-B	4.0	7.5	13.2	121.8	107.6	8.39×10^{-5}	SW	43.7	55.1	1.2	Gravely Sand	14,200
SS02-GT10-B	3.0	5.0	12.5	136.4	121.2	2.82×10^{-4}	GW	48.9	48.1	3.0	Sandy Gravel	19,200

pcf = pounds per cubic foot.

U.S.C.S. = Unified Soil Classification System.

Table 4-23 reports the moisture content, bulk (wet) density, dry density, grain size distribution, soil permeability (vertical hydraulic conductivity), and total organic carbon content of soil samples collected at Kotzebue LRRS. The following section discusses the results as applicable to the primary lithologies characterized at the site.

4.6.4.1 Beach Sands and Gravels. Geotechnical results for the three soil samples collected from the beach area (ST05-GT7-B, SS02-GT8-B, and SS02-GT10-B) indicate moisture contents between 11.6 and 13.2%, bulk densities between 121.8 and 138.3 lb/feet^3, and dry densities between 107.6 and 124.0 lb/feet^3. The gravelly Sands and sandy Gravels characterizing the beach area at Kotzebue LRRS produced the lowest mean moisture content (12.4%) and the highest mean bulk and dry densities (132.2 and 117.6 lb/feet^3, respectively) of the three lithologies characterized. Samples collected from the beach area produced the highest mean hydraulic conductivity (2.01 x 10^{-4} cm/sec), and lowest mean TOC concentration at 19,167 mg/kg (see Table 4-23).

The hydraulic conductivity of 8.39 x 10^{-5} cm/sec measured for sample SS02-GT8-B, collected from the fore-beach area, is somewhat lower than the hydraulic conductivities measured for the mid- and back-beach areas, 2.36 x 10^{-4} cm/sec and 2.82 x 10^{-4} cm/sec, respectively. This is a function of the slightly higher percentage of sand than gravel in the fore-beach sample than is present in the mid- and back-beach samples.

4.6.4.2 Tundra Silt. Geotechnical results for the native tundra soil samples (AOC8-GT1-T, AOC6-GT3-T, and AOC7-GT6-T) produced moisture contents between 34.0 and 49.5%, bulk densities between 105.6 and 116.9 lb/feet^3, and dry densities between 70.6 and 87.2 lb/feet^3. The silty soils that characterize native tundra produced the highest mean moisture content (40.4%) and the lowest mean bulk and dry densities (112.4 and 80.3 lb/feet^3, respectively) of the three lithologies characterized at Kotzebue LRRS. These samples also produced the lowest mean hydraulic conductivity (4.13 x 10^{-6} cm/sec), and the highest mean TOC concentration at 49,000 mg/kg (see Table 4-23).

Sample AOC6-GT4-F was collected to characterize gravel fill materials. However, this sample was collected from between the gravel fill and native soil contact and thus contained a significant percentage of silt which is typical of native tundra soils. The grain size analysis of this sample indicates 96.8% silt size material, therefore it has been included in the discussion of the tundra silt. Sample A0C6-GT4-F

is overlain by 3 feet of gravel fill and produced a slightly lower permeability than the other samples collected from native tundra (see Table 4-23).

4.6.4.3 Gravel Fill. Geotechnical results reported for two samples of gravel fill (AOC8-GT2-F and AOC4-GT5-F) indicated moisture contents between 13.1 and 26.8%, bulk densities between 123.8 and 134.8 lb/feet^3, and dry densities between 97.6 and 119.2 lb/feet^3. The gravel fill produced intermediate values for mean moisture content (20.0%), mean bulk density (129.3 lb/feet^3), mean dry density (108.4 lb/feet^3), mean hydraulic conductivity (1.68 x 10^{-4} cm/sec), and mean TOC concentration at 30,500 mg/kg, as compared to the beach area and native tundra lithologies (see Table 4-23). The TOC sample for AOC6-GT4-F was collected in gravel fill material at this location and therefore was included in this evaluation.

The wide variability observed in the permeabilities reported for samples AOC8-GT2-F and AOC4-GT5-F are indicative of the variability within the fill material (see Table 4-23). Sample AOC8-GT2-F was collected within the upper 6 feet of a thick section of fill material with a reported permeability of 3.35 x 10^{-4} cm/sec. Sample AOC4-GT5-F was collected to the base of gravel fill materials at a sample depth of 3 to 5 feet below ground surface with a reported vertical hydraulic conductivity of 1.37 x 10^{-6} cm/sec.

4.6.4.4 Discussion. The geotechnical and TOC samples collected to characterize the primary lithologies at Kotzebue LRRS as summarized in Table 4-23 support several general conclusions regarding contaminant migration. The tundra material has elevated TOC concentrations ranging from 30,500 to 79,200 mg/kg, very low hydraulic conductivities and elevated moisture contents. These results along with the fact that the tundra is predominantly silt size material will act to impede vertical migration of contamination. The beach sample test results had the highest vertical hydraulic conductivities of the three lithologies tested and they were quite typical of what one would expect from sandy gravels and gravelly sands. The moisture contents were also low as were the TOC concentrations. Contaminant migration would likely occur relatively unimpeded through these types of beach deposits. Contaminant migration through the fill material will not be as predictable as for the tundra and beach deposits. The hydraulic conductivity rates vary from those expected of beach sands to tundra material. Grain size distribution of the fill ranges from sandy gravel to silt. It is likely that contaminant migration will follow preferential

pathways through the fill material and migration rates would be rapid through the sandy gravel, but slow through the silt material.

4.6.5 Gradiometric Survey Results

In Figure 4-10, results of the gradiometric survey are summarized into two mapping categories, including buried metallic material and significant buried metallic material. The survey results include both mounded and non-mounded areas. However, metallic surface debris encountered during the survey is not included in the figure. Survey descriptions identifying surface conditions and interpreted gradiometric results are provided for each cell investigated in Appendix F. The cell location containing the tar disposal trench identified during the 1994 remedial investigation is identified as visible tar on Figure 4-10 (see Section 4.13, Interim Remedial Action).

Buried metallic material is defined by a low to moderate signal produced as the magnetic locator was passed over a relatively small but distinct area. For mapping purposes, a single signal within a 625-square-foot cell would include shading designated as buried metallic material in Figure 4-10. Significant buried metallic material is defined by a strong, sustained signal as the magnetic locator was passed over an area of about 10 square feet or larger within the 625-square-foot cell. The signal defining significant buried metallic material is similar to that detected during the survey of Cell C9 (tar disposal trench), prior to the interim remedial action. Approximately 40 buried drums were identified during the interim remedial action of the tar disposal trench (see Section 4.13, Interim Remedial Action).

The gradiometric survey identified 95 grid cells containing buried metallic material, and 18 cells containing significant buried metallic material (see Figure 4-10). Individual cell descriptions are provided in Appendix F. Survey results identify three main areas where buried metallic material have been detected within the former landfill boundaries, including a large area in the southern portion of the site (rows 1 through 23), a small localized area in the central portion of the landfill (rows 26 through 28), and a moderate size area in the northern area of the former landfill (rows 32 through 46). Each of these areas incorporate cells identified to contain significant buried metallic material (see Figure 4-10).

4.6.5.1 Discussion. Buried metallic material was detected and mapped during the gradiometric survey conducted at the former landfill, Site SS02-Waste Accumulation Area No. 2/Landfill. Approximately 40 shallow buried drums located about 3 feet below ground surface were removed from the tar disposal

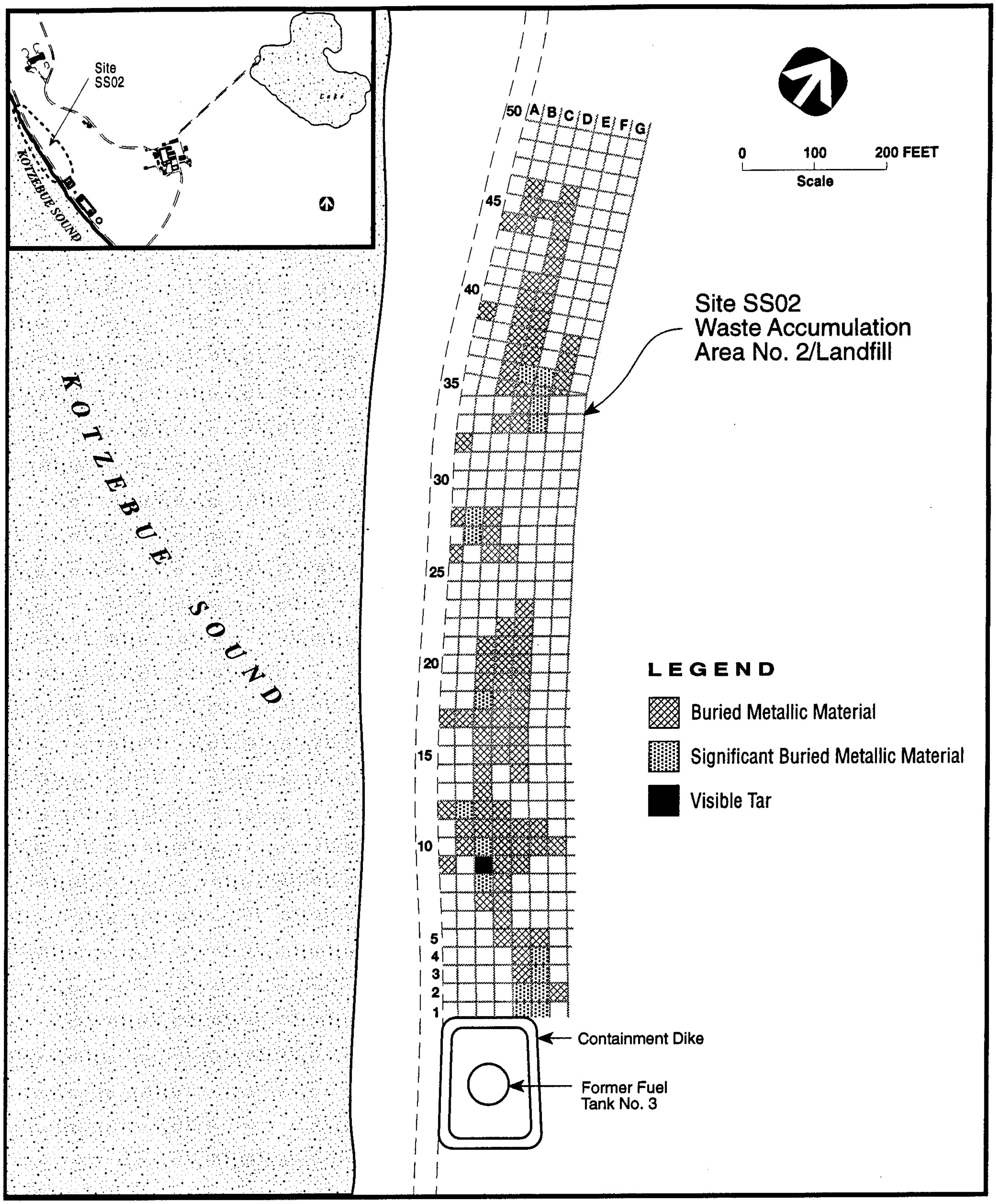

Figure 4-10. Gradiometric Survey Results at Site SS02-Waste Accumulation Area No. 2/Landfill, 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

trench. This drum removal occurred during an interim remedial action conducted in early October 1994 within the former landfill (see Section 3.10, Interim Remedial Action). Survey results indicate the detection of significant buried metallic material in the cell containing the former tar disposal trench. Similar signals detected in other areas (grid cells) of the site may or may not indicate the presence of buried drums. It is important to note that magnetic locators are very susceptible to noise caused by some natural soil conditions. Additionally, magnetic locators are limited in providing quantitative data concerning the number and depth of identified targets. This survey should be viewed as a qualitative method of identifying potential "hot spots" that may contain buried metallic waste such as drums. However, excavation is required to distinguish buried drums from other innocuous metallic debris.

4.6.6 Natural Attenuation Assessment Results

This section discusses the results of the natural attenuation assessment conducted for soil, surface water, and groundwater at Kotzebue LRRS.

4.6.6.1 Soil (Hydrocarbon Chain Ratio Results). Table 4-24 provides straight-chain alkane and branched-chain hydrocarbon data for Sites SS12 and ST05. Data provided for both alkane and branched-chain hydrocarbons are normalized weight ratios (ug/mL) representing the mass of the contaminant relative to the arctic diesel standard as calculated from peak areas.

Although the branched-chain hydrocarbon benchmarks (B1 through B4) have been closely matched to a limited set of potential compounds, the branched-chain hydrocarbons need not be directly associated to a specific alkane (e.g., C12/B1) for ratio analysis. Some statistical variability is observed in the relative amounts of selected branched-chain hydrocarbons between samples. For the purpose of this study the branched-chain compounds (B1 through B4) and the alkanes (C_9 through C_{16}) have been summed and ratio calculated for the summations (see Table 4-24). The summed alkane/branched-chain ratios effectively normalize the data by reducing statistical variability between individual compounds.

Ratios from samples that were rerun with dilution or analyzed in duplicate have been included to show that only a small variation in alkane/branched-chain ratios occur about the mean value, confirming the robust nature of normalized weight quantitation as a basis for calculating the ratio.

TABLE 4-24. SUMMARY OF HYDROCARBON CHAIN RATIOS FOR ALKANE VERSES BRANCHED-CHAIN HYDROCARBON DATA, 1994 REMEDIAL INVESTIGATION, KOTZEBUE LRRS, ALASKA

Sample Designation	Description	Ratio of Straight to Branched	Sum of Straight Chain Alkanes (ug/mL)	Sum of Branched Chain Compound (ug/mL)	Straight-Chain Alkane (ug/mL)								Branched-Chain Hydrocarbon (ug/mL)			
					C9	C10	C11	C12	C13	C14	C15	C16	B1	B2	B3	B4
Arctic Diesel Std.	500 ug/mL Std.	2.00	4000	2000	500	500	500	500	500	500	500	500	500	500	500	500
Site SS12																
SS12-SB15-1.5	1:2 Dil.	0.50	45574.39	91629.90	135.52	684.11	3431.26	6032.62	7740.41	6741.75	8011.22	12797.50	22748.20	28652.70	24650.50	15578.50
SS12-SB15-1.5	Rerun,1:40 Dil.	0.47	3187.58	6759.90	10.67	40.33	227.64	415.17	503.56	480.68	525.15	984.39	1483.91	2153.48	1931.61	1190.90
SS12-SB20-1.0	1:2 Dil.	0.87	39982.62	46101.83	32.27	293.09	1569.55	3503.33	5554.87	7456.41	8887.19	12685.90	7452.53	11190.70	15057.10	12401.50
SS12-SB20-1.0	Duplicate	0.88	36386.08	41191.21	37.78	303.36	1594.01	3522.64	5701.25	6441.59	7339.16	11446.30	7185.91	11032.80	12423.50	10549.00
SS12-SB20-1.0	Rerun	0.84	3955.45	4710.83	3.27	40.42	162.46	402.77	634.37	690.06	761.19	1260.92	786.71	1407.01	1383.64	1133.47
SS12-SB20-1.0	Rerun,1:20 Dil.	0.84	4695.35	5581.78	3.44	44.71	180.45	462.60	775.87	851.04	896.39	1480.85	987.80	1666.64	1644.72	1282.62
SS12-SB24-1.0	1:2 Dil.	0.74	26970.01	36514.50	14.65	224.29	1712.73	3665.65	5052.78	4619.19	4897.56	6783.16	8062.22	11289.50	9763.87	7398.91
SS12-SB24-1.0	Rerun, 1:20 Dil.	0.72	3364.03	4651.22	Not Found	30.42	185.81	470.41	634.31	554.53	550.91	937.65	1033.46	1463.15	1250.73	903.77
Site ST05																
ST05-SB22-8.5		1.00	18.50	18.45	0.90	Not Found	Not Found	Not Found	0.77	1.27	4.14	11.42	2.23	5.38	7.98	2.86
ST05-SB24-8.0	Medium	0.82	14771.32	18022.21	28.77	258.16	1446.09	2478.99	2720.52	2628.68	2321.63	2888.48	4819.12	5489.50	4630.75	3082.84
ST05-SB24-8.0	Med., 1:5 Dil.	0.79	2762.14	3488.89	3.63	53.07	266.29	532.66	535.52	446.03	386.78	538.15	904.73	1170.62	874.89	538.65
ST05-SB08-4.0	1.3 Dil.	0.42	23137.15	55260.20	114.37	526.77	1819.29	3013.42	3307.38	3093.02	3808.28	7454.62	12296.60	17004.20	15920.80	10038.60
ST05-SB08-4.0	1:36 Dil.	0.39	2109.82	5447.79	9.05	56.24	174.37	277.92	301.96	298.86	326.10	665.32	1054.86	1872.12	1578.41	942.40

Site SS12-Spills No. 2 and 3--The alkane/branched-chain ratio is calculated to be 2.0 for the unweathered Arctic diesel standard (see Table 4-24). Weathered soil sample results reveal carbon ratios from 0.47 to 0.84 (58 to 74 percent ratio reduction), indicating a loss of straight-chain compounds relative to the branched. Figure 4-11 provides chromatographic evidence in support of active natural attenuation at Site SS12. The arctic diesel standard (source material) is represented at the top of the figure with weathered soil samples nearest to the source below. A significant decrease in straight-chain hydrocarbons can be observed in Sample SB15, where the branched-chain hydrocarbons have actually become dominant, indicative of a degraded diesel fuel (Christensen and Larson 1993). Sample SB15 was collected closest to the source area (approximately 750 feet between upper and downgradient sample locations) (see Figure 4-6).

Site ST05-Beach Tanks--The ratio of straight to branched chain hydrocarbons for the unweathered arctic diesel standard is 2.0. Weathered soil samples reveal a loss of straight-chain hydrocarbons relative to branched from 0.79 in Sample ST05-SB24 to 0.39 in Sample ST05-SB08 using the final dilution sample values (see Table 4-24). Figure 4-12 provides chromatographic evidence in support of active natural attenuation at Site ST05. The arctic diesel standard (500 μg/mL) represents original unweathered source material. Sample ST05-SB22 is a background sample collected directly upgradient of the source area (see Figure 4-6). The background sample does not reveal the branched chain benchmarks identified in arctic diesel and associated weathered soil samples, supporting the assumption that the identified branch chain hydrocarbons are components of the arctic diesel standard. Sample ST05-SB24 was collected within the suspected source area and represents the highest DRO concentration observed in site soils (see Figure 4-6). The reduction in alkane to branched-chain hydrocarbons can be observed in Figure 4-12 and indicates natural attenuation is occurring. Sample ST05-SB08 is located immediately downgradient between the suspected source area and Kotzebue Sound. This sample shows the predominance of branched-chain compounds relative to the straight-chain alkanes (see Figure 4-12).

Discussion--This study presents a means by which refractory branched-chain hydrocarbons are interpreted to be an indication of the occurrence of natural attenuation in soils with arctic-grade diesel fuel contamination. Several processes may act to change the concentration and composition of petroleum hydrocarbon contamination in the environment over time. Three important processes are volatilization, leaching, and microbial (biodegradation) activity (Christensen and Larson 1993). Volatilization results in loss of the lighter-fraction hydrocarbons resulting from their higher vapor pressures. Lighter-end

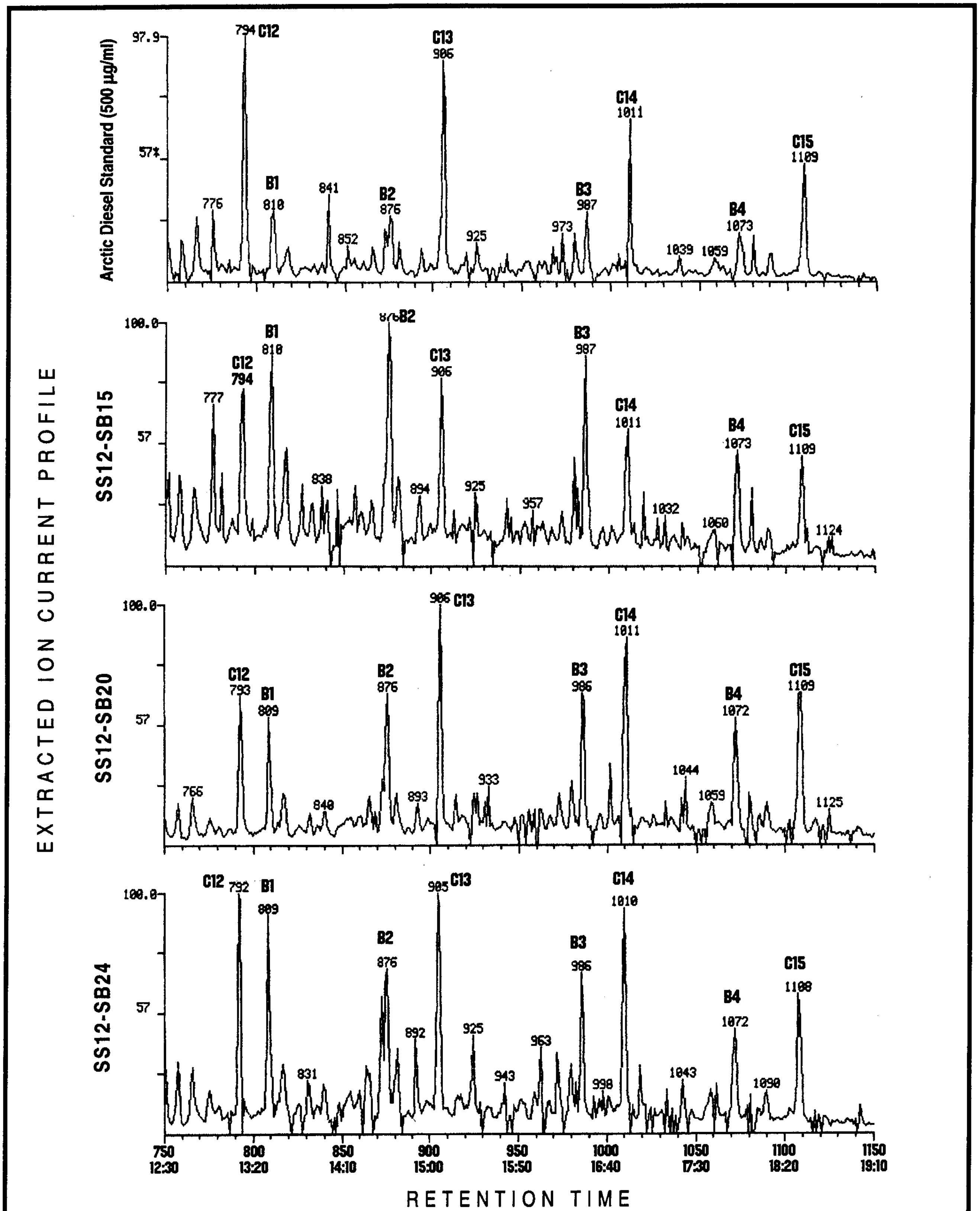

Figure 4-11. Chromatographic Evidence in Support of Natural Attenuation at Site SS12-Spills No. 2 and 3, 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

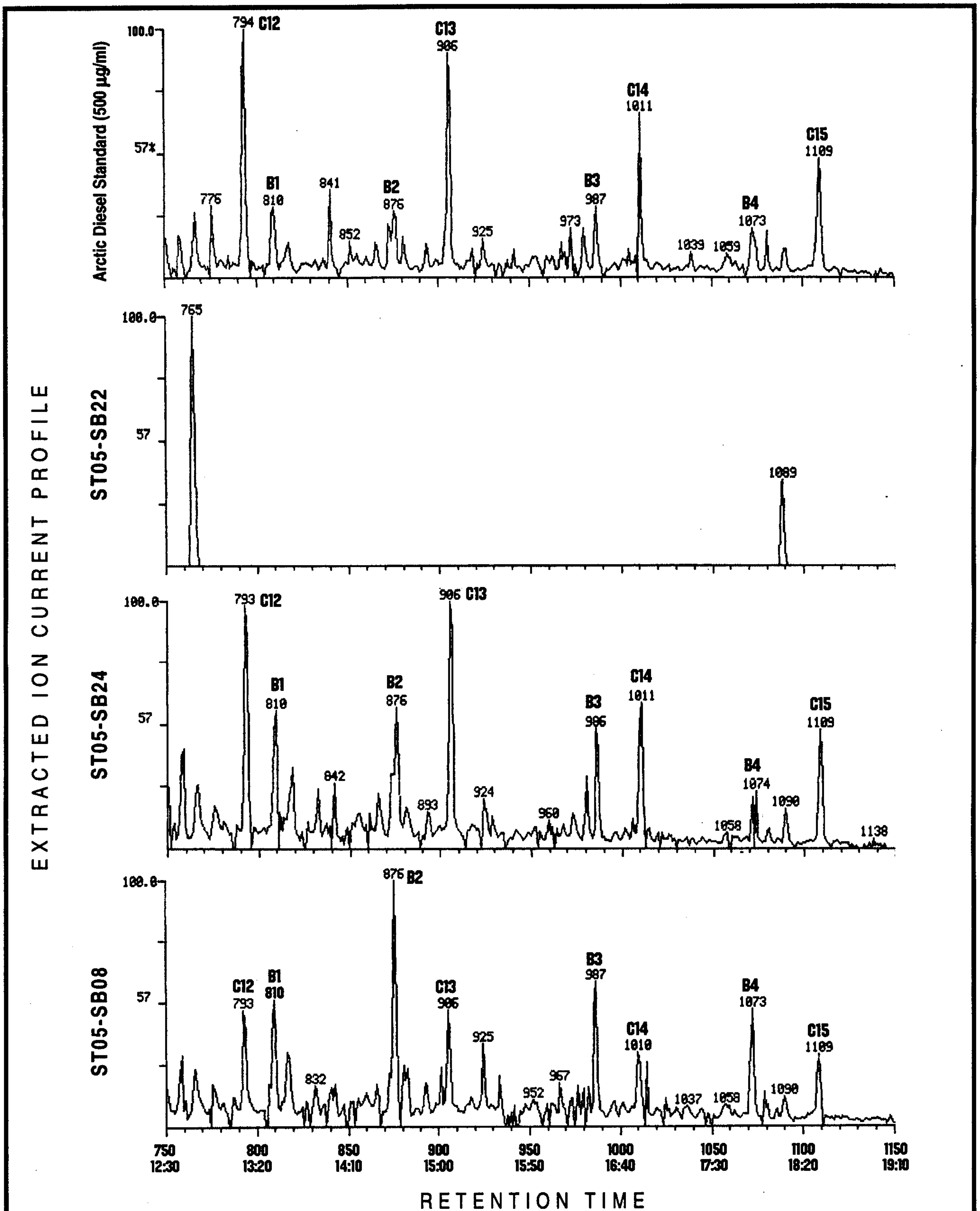

Figure 4-12. Chromatographic Evidence in Support of Natural Attenuation at Site ST05-Beach Tanks, 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

hydrocarbons through C_{10} to C_{11} have been significantly reduced in all weathered soil samples associated with this study. Leaching causes the removal of more water soluble components which is again typically related to the lighter-fraction hydrocarbons (e.g., BETX compounds). As a class, petroleum hydrocarbons are biodegradable. The lighter, more soluble members are generally biodegraded more rapidly and to lower residual levels than are the heavier, less soluble members. Thus, monoaromatic compounds such as benzene, toluene, ethylbenzene, and the xylenes are more rapidly degraded than the two-ring compounds such as naphthalene, which are in turn more easily degraded than the three-, four-, and five-ring compounds. The same is true for aliphatic compounds where the smaller compounds are more readily degraded than the larger compounds. Branched hydrocarbons degrade more slowly than the corresponding straight-chain hydrocarbons (Norris et al. 1994).

The degradation of straight-chain hydrocarbons (C_{12} through C_{15}) observed in soil samples analyzed during this study is suspected to be a primary result of natural biodegradation processes, where straight-chain hydrocarbons are preferentially degraded by indigenous microorganisms. In a previous IRP investigation conducted at Kotzebue LRRS microbial enumeration was performed on two soil and two groundwater samples collected at Site ST05 (see Section 3.2, Stage 2 RI/FS). Microbial enumeration indicated the presence of phenanthrene degraders at densities suggesting that organic contamination present in the groundwater at Kotzebue LRRS has induced some microorganisms to develop the capacity to metabolize phenanthrene. Since the metabolic pathway for this compound is similar to the pathway for a number of organic constituents of diesel (Chapman 1979), the data suggested that natural biodegradation of other chemical constituents of diesel may also be occurring (USAF 1990b). Additionally, geochemical evidence that natural biodegradation is actively occurring in the near-beach aquifer at Kotzebue LRRS is presented in Section 4.6.6.2, Near-Beach Groundwater Flowpath, of this report.

The observed decrease in alkane/branched-chain hydrocarbon ratios in all contaminated soils associated with this study, and the identification of indigenous hydrocarbon degraders within the Site ST05 study area, demonstrate that natural attenuation is occurring, and that biodegradation may be a significant process in site soils at Kotzebue LRRS. Although the carbon ratio study indicates natural attenuation is occurring at Kotzebue LRRS, it does not directly address the rate at which diesel fuel contamination is being removed from the environment. However, the observed revegetation along the hillslope of the SS12-Spill No. 3 site indicates that a reduction in TPH is likely occurring. Natural attenuation represents

a non-invasive, non-destructive alternative to material removal actions or other approaches that would negatively impact the fragile native tundra and local ecosystem at Kotzebue LRRS.

4.6.6.2 Near-Beach Groundwater Flowpath. A summary of geochemical test results for groundwater samples collected from the near-beach aquifer at Kotzebue LRRS is provided in Table 4-25. Groundwater contamination at Kotzebue LRRS is concentrated along the fore-beach area immediately downgradient of Site ST05-Beach Tanks (see Section 7.5, Site ST05-Beach Tanks). The evaluation of changes in groundwater geochemistry as groundwater moves through the contaminant source area requires the characterization of upgradient (natural) groundwater conditions. Two back-beach monitoring wells were installed to evaluate background conditions at Site ST05. However, diesel range organics was detected at relatively low concentration (0.22 mg/L) in back-beach monitoring well ST05-MW7. Monitoring well ST05-MW4 revealed no detected contaminant concentrations. The near-beach groundwater flow direction is estimated to the southwest toward Kotzebue Sound (see Section 4.6.1, Water Level Measurements). Therefore, monitoring wells ST05-MW4 (back-beach), MW5 (mid-beach) and MW6 (fore-beach) were selected to evaluate the near-beach groundwater flow path at Kotzebue LRRS.

Groundwater geochemical trends have been summarized below for the MW4-MW5-MW6 flowpath to provide discussion regarding natural attenuation and seawater mixing in the near-beach aquifer at Kotzebue LRRS.

NEAR-BEACH GROUNDWATER													
		Select Geochemical Parameters (mg/L)											
								Inorganic Elements (mg/L)					
Sample Designation	DROs (mg/L)	D.O. (O_2)	CO_2	Nitrate (NO_3)	Sulfate (SO_4)	Temperature (^{o} C)	Conductivity (umhos/cm)	Na	K	Cl	Mg	Fe
MW4 (Back-Beach)	ND	3.8	25	<0.02	<50	4.0	220	3.97	1.1	60	12.3	3.4
MW5 (Mid-Beach	2.2	0.6	65	<0.02	<50	3.0	320	17.7	3.1	40	21.5	16.1
MW6 (Fore-Beach)	14	0.5	105	<0.02	60	3.0	2,100	562	21.0	760	54.9	16.5

TABLE 4-25. SUMMARY OF GEOCHEMICAL TEST RESULTS FOR SITE ST05 GROUNDWATER
1994 REMEDIAL INVESTIGATION, KOTZEBUE LRRS, ALASKA

Test	Method/Kit	Fore-Beach Area Groundwater (mg/L)				Mid-Beach Area Groundwater (mg/L)			Back-Beach Area Groundwater (mg/L)	
		ST05-MW6	ST05-MW8	ST05-MW9	SS02-MW3	ST05-MW5	ST05-MW2	ST05-MW3	ST05-MW7	ST05-MW4
Hydrogen sulfide (H_2S)	Field Test (HS-C)	<0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Field Test (HS-WR)	<0.01	0.3	0.12	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Carbon dioxide (CO_2)	Field Test (CA-23)	105	125	75	35	65	75	40	70	25
Nitrite (NO_2)	Field Test (NI-15)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ammonia nitrogen (NH_4)	Field Test (NI-SA)	0.8	<0.1	<0.1	<0.1	0.1	0.26	<0.1	<0.1	<0.1
Chloride (NaCl)	Field Test (8-P)	760	500	25	180	40	40	20	20	60
Nitrate nitrogen (NO_3)	Field Test (NI-14)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Sulfate (SO_4)	Field Test (SF-1)	60	130	<50	<50	<50	<50	<50	<50	<50
Phosphate, Ortho (P)	Field Test (PO-19)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Alkalinity-P	Field Test (AL-DT)	0	0	0	0	0	0	0	0	0
Alkalinity-T ($CaCO_3$)	Field Test (AL-DT)	560	450	330	280	228	515	266	300	188
Dissolved oxygen	Field Measurement	0.5	1.0	1.4	1.8	0.6	NA	1.0	1.2	3.8
pH	Field Measurement	6.50	6.79	6.77	7.54	6.23	7.25	6.93	6.64	7.09
Temp. ^{o} C	Field Measurement	3.0	3.0	3.0	3.5	3.0	3.0	3.0	3.5	4.0
Conductivity (μmhos/cm)	Field Measurement	2,100	1,400	340	400	320	550	280	330	220
Total Organic Carbon	EPA Method 9060	7.7	48.8	40.2	10.5	11.1	16.2	12.5	11.8	8.29
Total Metals										
(Fe) Iron	EPA Method 6010	16.5	14.2	10.4	5.20	16.1	41.0	2.15	6.59	3.43
(Na) Sodium	EPA Method 6010	562	184	47.9	124	17.7	19.6	5.30	7.61	3.97
(K) Potassium	EPA Method 6010	21.0	11.0	7.8	9.8	3.1	4.8	3.3	1.4	1.1
(Ca) Calcium	EPA Method 6010	81.1	125	82.1	25.6	93.8	130	102	107	67.7
(Mg) Magnesium	EPA Method 6010	54.9	43.1	18.9	16.6	21.5	34.1	12.2	20.1	12.3

During aerobic biodegradation, dissolved oxygen levels are reduced as aerobic respiration occurs. After dissolved oxygen has been depleted, nitrate (NO_3) and subsequently sulfate (SO_4) concentrations may be reduced by anaerobic biodegradation (Wiedermeier et al. 1994). During anaerobic biodegradation ferric iron (Fe^{+3}) may be reduced to the ferrous form (Fe^{+2}) which may be soluble in water. Therefore, an increase in iron concentration along the groundwater flowpath may be an indication of anaerobic biodegradation. The above table shows that dissolved oxygen (0_2) decreases from 3.8 mg/L to 0.5 mg/L along the MW4-MW5-MW6 groundwater flow path. Nitrate was not detected in groundwater (i.e., <0.02 mg/L). Sulfate was detected at 65 mg/L in the downgradient monitoring well ST05-MW6 (see above table). Iron (Fe) increases from 3.4 mg/L to 16.5 mg/L along the MW4-MW5-MW6 groundwater flow path (see above table).

Carbon Dioxide (CO_2) increases from 25 mg/L in background well MW4 to 105 mg/L in well MW6 (see above table). Metabolic processes operating during biodegradation of fuel hydrocarbons lead to the production of carbon dioxide. If the carbon dioxide produced during metabolism is not removed by the natural carbonate buffering system of an aquifer, carbon dioxide levels higher than background may be observed (Wiedermeier et al. 1994).

Despite the geochemical trends that indicate biodegradation may be occurring along the flowpath, DROs contamination is concentrated downgradient of the suspected source area (e.g., former Beach Tanks). The increase in groundwater DRO concentrations along the flow path may result from the relatively short distance of the flow path and elevated soil DRO values. Large increases in the concentration of sodium (Na), potassium (K), magnesium (Mg), chloride (Cl), and electrical conductivity between the MW5 and MW6 groundwater samples indicate that seawater is mixing with shallow groundwater along the upper beach face, where MW6 is located (see above table). The presence of elevated chloride (Cl) in MW6 groundwater may inhibit biodegradation, resulting in increased groundwater DRO concentrations at this location. Another factor that may be inhibiting biodegradation are low groundwater temperatures, which decrease from 4^{o} C at MW4 to 3^{o} C at MW6. Groundwater temperatures below 5^{o} C are known to inhibit biodegradation rates (Wiedermeier et al. 1994).

Discussion--Recharge to the near-beach aquifer is likely controlled by the highly seasonal nature of the suprapermafrost water that recharge the beach area from the tundra uplands. The observed decrease in dissolved oxygen and increase in carbon dioxide as groundwater moves along the MW4-

MW5-MW6 flowpath may be an indication that aerobic biodegradation processes are active. The relatively low dissolved oxygen levels measured in monitoring wells MW5 and MW6 along with an increase in iron concentration along the groundwater flowpath may be an indication anaerobic biodegradation is also occurring. However, anaerobic bacteria generally cannot function at dissolved oxygen levels greater than approximately 0.5 mg/L (Wiedermeier et al. 1994).

Previous IRP investigations of the near-beach aquifer at Kotzebue LRRS identify indigenous microorganism populations capable of metabolizing organic constituents of diesel fuel (see Section 4.6.6.1, Soils) carbon ratio analysis in petroleum contaminated soils at Site ST05 indicate that natural attenuation is active in the near-beach subsurface and that biodegradation processes are occurring. Changes in groundwater geochemistry as groundwater moves through the source area at Site ST05 indicate biodegradation may be occurring in the near-beach aquifer. Although there are indications of active biodegradation in the near-beach aquifer the rate of contaminant degradation is effected by low groundwater temperatures which can inhibit biodegradation rates. Additionally, geochemical test results indicate a lack of basic nutrients (e.g., nitrogen and phosphate) in the near-beach aquifer, limiting the potential growth of indigenous microorganisms capable of metabolizing petroleum hydrocarbons (see Table 4-25).

4.6.6.3 Surface Water Flowpath. A summary of geochemical test results for surface water samples collected from three locations at Site SS12 and from a background location is provided in Table 4-26. The background surface water sample location is approximately one mile north from the surface water flowpath samples in a different drainage (see Figure 4-7). As such, the background sample is not considered in conjunction with the three samples that comprise the surface water flowpath, SW1, SW3, and SW4, upgradient to downgradient, respectively (see Figure 4-6).

Surface water flowpath geochemical trends have been summarized in the data table below to provide discussion regarding active natural attenuation processes at Site SS12, Kotzebue LRRS.

TABLE 4-26. SUMMARY OF GEOCHEMICAL TEST RESULTS FOR SITE SS12 SURFACE WATERS, 1994 REMEDIAL INVESTIGATION, KOTZEBUE LRRS, ALASKA

Test	Method/Kit	Surface Water (mg/L)			
		Background-SW2	SS12-SW1	SS12-SW3	SS12-SW4
Hydrogen sulfide (H_2S)	Field Test (HS-C)	<0.1	0.1	0.1	<0.1
	Field Test (HS-WR)	<0.01	<0.01	<0.01	<0.01
Carbon dioxide (CO_2)	Field Test (CA-23)	5	60	30	15
Nitrite (NO_2)	Field Test (NI-15)	<0.01	<0.01	<0.01	<0.01
Ammonia nitrogen (NH_4)	Field Test (NI-SA)	<0.1	<0.1	<0.1	<0.1
Chloride (NaCl)	Field Test (8-P)	88	80	72	64
Nitrate nitrogen (NO_3)	Field Test (NI-14)	<0.02	<0.02	<0.02	<0.02
Sulfate (SO_4)	Field Test (SF-1)	<50	<50	<50	<50
Phosphate, Ortho (P)	Field Test (PO-19)	<0.02	<0.02	<0.02	<0.02
Alkalinity-P	Field Test (AL-DT)	0	0	0	0
Alkalinity-T ($CaCO_3$)	Field Test (AL-DT)	13	185	116	60
Dissolved oxygen	Field Measurement	9.05	5.00	5.00	9.00
pH	Field Measurement	5.60	7.89	6.98	6.81
Temp. ^{o} C	Field Measurement	11	16.5	16.3	14.0
Conductivity (μmhos/cm)	Field Measurement	40	1,050	250	60
Total Organic Carbon	EPA Method 9060	28.0	186	55.1	37.8
Total Metals					
(Fe) Iron	EPA Method 6010	0.55	3.98	1.23	0.21
(Na) Sodium	EPA Method 6010	5.3	23.9	14.2	8.87
(K) Potassium	EPA Method 6010	0.7	0.6	0.2	0.2
(Ca) Calcium	EPA Method 6010	3.2	124	42.1	17.7
(Mg) Magnesium	EPA Method 6010	1.8	41.0	11.3	5.17

SURFACE WATER						
		Select Geochemical Parameters				
Sample Description	DROs (mg/L)	CO_2 (mg/L)	DO (mg/L)	Fe (mg/L)	TOC (mg/L)	TEMP (^{o} C)
BKGD	ND	5	9.0	0.55	28	11
SW1	8.0	60	5.0	3.98	186	16.5
SW3	2.0	30	5.0	1.23	55	16.3
SW4	0.14	15	9.0	0.21	38	14.0

DRO concentrations decrease significantly from upgradient to downgradient samples indicating that natural attenuation processes are acting to reduce DRO concentrations with distance from the contaminant source. However, geochemical trends do not support a biodegradation process to account for the reduced DRO concentrations, despite relatively high surface water temperatures (see table above) that could support biodegradation. The dissolved oxygen concentrations measured along the surface water flow path indicate that aerobic rather than anaerobic conditions would control biodegradation processes. If anaerobic biodegradation was the dominant process reducing DRO concentrations along the flowpath, iron (Fe) and ammonia (NH_4) would be expected to increase in concentration. The opposite trends are exhibited by the data. If aerobic biodegradation processes were reducing DRO concentrations along the flow path, carbon dioxide (CO_2) would be expected to increase in concentration while dissolved oxygen should decrease. Although the opposite trends are exhibited by the data (see table above), oxygen exchange between surface water and ambient air limits the potential to measure changes in these parameters due to biodegradation.

Discussion–The data for the surface water flowpath taken as a whole indicated that other attenuation processes such as photolysis, hydrolysis, or abiotic oxidation may be responsible for the observed reduced DRO concentrations. Alternatively, purely physical processes such as sorption, volatilization, or dilution may account for the observed DRO concentrations.

Specific locations along the flowpath may nonetheless support the biodegradation of DRO compounds. This is particularly true for location SW1, which exhibits elevated carbon dioxide (CO_2) concentration relative to the other surface water sample locations (see Table 4-26). To a lesser extent, some suggestion

of active biodegradation is exhibited by the analytical results for sample SW3 with respect to the data for SW4. Other mechanisms for the reduction of DRO concentrations along the surface water flowpath, especially downgradient of SW1, are more plausible. Carbon ratio analysis of TPH contaminated soil samples collected along the surface water flowpath at Site SS12 indicate that natural attenuation is actively occurring along this surface pathway (see Section 4.6.6.1, Soils).

4.6.7 Background Characterization

The following sections provide discussion of analytical results associated with media specific background characterization as presented in Table 4-5. A summary of maximum contaminant concentrations detected in background media is provided by analytical method in Tables 4-12 through 4-21. Sample-specific results for all background samples collected at Kotzebue LRRS is provided in Appendix L.

4.6.7.1 Soil Sample Results. Three soil samples were collected in native tundra and three beach soil/sediment samples in the vicinity of the site to evaluate background conditions (see Figure 4-7). All background soil samples were analyzed for DROs, VOCs, SVOCs, pesticides and PCBs, and total metals. Additionally, three soil samples (native tundra) were submitted for GROs analysis. The analytical results revealed the following:

- Gasoline Range Organics (Method AK101): No gasoline range organics were detected in background soil samples

- Diesel Range Organics (Method AK102): Diesel range organics was detected at relatively low concentrations in background Samples SS3 at 11 mg/kg and SS4 at 43 mg/kg. However, Sample SS2-01 revealed a DRO concentration of 1,200 mg/kg. Based on the elevated concentration observed in Sample SS2-01, a second sample (SS2-02) was collected from a location approximately 200 yards upgradient, and analyzed for TPH. Sample SS02-02 revealed a DRO concentration of 3,800 mg/kg (see Figure 4-7). No visual or olfactory evidence of petroleum contamination was noted during background sample collection.

- VOCs (Method SW8260): Total xylenes were detected in soil at two background locations, including background Sample SS1B-01 at an estimated concentration of

0.003 mg/kg, and in Sample SS4-01 at 0.014 mg/kg. In addition, ethylbenzene at an estimated 0.0015 mg/kg and toluene at 0.0043 mg/kg were detected in Sample SS4-01.

- SVOCs (Method SW8270): The only semivolatile compounds detected in background soils were benzyl alcohol and benzoic acid at a maximum concentration of 0.1 mg/kg and 1.0 mg/kg, respectively.

- Pesticides/PCBs (Method SW8081): The Aroclor 1260 was detected in a single background sample (SS1A-01) at an estimated concentration of 0.02 mg/kg. The pesticides 4,4'-DDE, 4,4'-DDD, and 4,4'-DDT were detected in background soils at a maximum concentration of 0.0039 mg/kg, 0.0035 mg/kg, and 0.05 mg/kg, respectively.

- Metals (Method SW6000, 7000 Series): Table 4-15 provides maximum detected concentrations for inorganic compounds in background soils/sediment. Arsenic was detected at an elevated concentration of 800 mg/kg in background Sample SB1-10.5. Sample SB1-10.5 was collected from 10.5 feet below ground surface during the installation of background monitoring well MW1. The elevated detection of arsenic in Sample SB1-10.5 is considered an outlier and was not used in the determination of mean background concentration.

Sediment Sample Results--Three sediment samples (Background-SD2, SD3, and SD4) were collected from surface water (lake) locations to evaluate background conditions (see Figure 4-7). All background sediment samples were analyzed for the presence of DROs, VOCs, SVOCs, pesticides and PCBs, and total metals. The analytical results revealed the following:

- Diesel Range Organics (Method AK102): Diesel range organics were detected in background Samples SD2-01 at 380 mg/kg, SD3-01 at 16 mg/kg, and SD4-01 at 45 mg/kg.

- Residual Range Organics (Method Extended-AK102): Background Sample SD2-01 was selected to evaluate RROs in background sediment. RROs were detected at 1,100 mg/kg. Results indicated that motor oil was not identified, although RROs were elevated in relation to DROs concentration.

- VOCs (Method SW8260): Toluene was detected in a single background sediment sample (SD2-01) at 0.094 mg/kg.

- SVOCs (Method SW8270): The only semivolatile compound detected in background sediment was benzoic acid at an estimated concentration of 0.93 mg/kg.

- Pesticides/PCBs (Method SW8081): The following pesticides were detected in sediment including 4,4'-DDE at 0.0034 mg/kg, 4,4'-DDD at 0.022 mg/kg, and 4,4'-DDT at 0.0026 mg/kg.

- Metals (Method SW6000, 7000 Series): Table 4-15 provides maximum detected concentrations for inorganic compounds in background soils/sediment.

Surface Water Sample Results--Three surface water samples (SW2, SW3 and SW4) were collected to evaluate background concentrations in the vicinity of the site. Background sample locations for surface water samples are presented in Figure 4-7. All background surface water samples were analyzed for DROs, VOCs, SVOCs, pesticides and PCBs, and both total and dissolved metals. A suite of geochemical parameters were collected at background location SW7 to provide background concentrations for surface water in an area unaffected by petroleum hydrocarbon concentrations. These data were used to evaluate geochemical results for surface water samples collected at Site SS12-Spills No. 2 and 3 in support of the evaluation of natural biodegradation. The analytical results revealed the following:

- Diesel Range Organics (Method AK102): Diesel range organics were not detected in background surface water samples.

- VOCs (Method SW8260): No volatile organic compounds were detected in background surface water samples.

- SVOCs (Method SW8270): No semivolatile organic compounds were detected in background surface water samples.

- Pesticides/PCBs (Method SW8081): No pesticides or PCBs were detected in background surface water samples.

- Metals (Method SW6000 Series): Table 4-20 provides maximum concentrations of inorganic compounds detected in surface water samples.

Sea Water Sample Results--One sea water sample (SW1) was collected to evaluate background conditions in Kotzebue Sound. The sea water sample was analyzed for DROs, VOCs, and SVOCs. No detected compounds were identified for the analyses performed.

Groundwater Sampling--One background groundwater monitoring well was installed north of Site SS02 in an area with no known source of contamination. One groundwater sample (Background-MW1-01) was collected from this well to evaluate background groundwater conditions. The background groundwater sample was analyzed for DROs, VOCs, SVOCs, pesticides and PCBs, and both total and dissolved metals. The analytical results revealed the following:

- Diesel Range Organics (Method AK102): Diesel range organics were not detected in background Sample MW1-01.

- VOCs (Method SW8260): No volatile organic compounds were detected in background Sample MW1-01.

- SVOCs (Method SW8270): No semivolatile organic compounds were detected in background Sample MW1-01.

- Pesticides/PCBs (Method SW8081): No pesticides or PCBs were detected in background Sample MW1-01.

- Metals (Method SW6000, 7000 Series): Table 4-20 provides maximum concentrations for inorganic compounds detected in background Sample MW1-01.

5.0 SITE CONCEPTUAL MODEL

The primary purpose of the site conceptual model is to integrate available site information, identify additional data needs, facilitate the selection of remedial designs, and guide the risk assessment process. The Kotzebue LRRS site conceptual model was based on site characterization information obtained during the 1994 remedial investigation and on a review of information collected during past IRP investigations.

5.1 BACKGROUND CHARACTERIZATION AND SITE CONTAMINANT IDENTIFICATION

No background concentrations were characterized previous to the 1994 IRP investigation conducted at Kotzebue LRRS. During the 1994 RI, background concentrations were characterized to provide the baseline concentration data necessary to evaluate site-specific samples collected from each media and source area during field sampling. Such evaluations are used to delineate source areas, recommend remedial actions, and evaluate media-specific concentrations relative to ARARs for the individual sites. Background characterization included all analyses performed and media (i.e., soil, sediment, surface water, and groundwater) sampled during the investigation (see Table 4-5). Background characterization was conducted at four station locations adjacent to Kotzebue LRRS (see Section 4.4.10, Background Characterization). Background characterization results are discussed by media in Section 4.6.7, Background Characterization Results). Maximum background concentrations detected at Kotzebue LRRS are summarized by media and analytical method in Section 4.5, Summary of Analytical Results; Tables 4-12 through 4-21. A detailed description of IRP activities conducted at each site and area of concern investigated at Kotzebue LRRS is provided in Section 7.0, Summary of Site Status and Recommendations. Section 7.0 includes sample station locations for sites and areas of concern investigated during the 1994 RI.

5.1.1 Data Evaluation

There are several factors to consider in assessing the useability of environmental data for use in baseline risk assessments (EPA 1989). In addition to the data quality criteria goals, the source, documentation,

analytical methods/detection limits and level of review associated with the data can all affect the useability.

Based on RI data reviewed and data validation results, the quality criteria goals for accuracy, precision, and completeness were met. All data gathered during the field effort at Kotzebue LRRS were reported in the Analytical Data Informal Technical Information Report (ITIR). All data reviewed, including the resulting qualified data (as required), are provided in the Analytical Data ITIR (USAF 1995c).

Documentation of field and laboratory procedures is important so the effect of any deviation from these procedures on data useability can be assessed. Extensive documentation was prepared for the RI (USAF 1994a,b,c,d). In addition, both field and laboratory audits were performed. No deviations from project guidelines were noted which would adversely affect the useability of the analytical data (see Appendix J; Quality Assurance Report).

The level of analytical data review can also effect data useability. All data used for baseline assessment were subject to a thorough data reduction and validation process, as discussed in Section 4.3, Analytical Program, and presented in the Analytical Data ITIR (USAF 1995c).

5.1.2 Contaminant Identification

Chemicals of potential concern (COPC) were identified and evaluated for use in a baseline risk assessment at Kotzebue LRRS (USAF 1995b). The identification of COPCs for both human health and ecological risk assessment is discussed in the following sections.

5.1.2.1 Chemicals of Potential Human Health Concern. A screening of the contaminant data was performed to determine which chemicals might pose a potential human health risk (USAF 1995b). The screening consisted of the following four steps: 1) compare maximum detected concentration for each chemical in each medium with risk-based screening concentrations (RBCs), 2) compare maximum PQLs to RBCs for chemicals which were not detected, 3) identify organic chemicals which were detected but for which no RBCs are available, and 4) compare maximum concentrations to mean background concentrations for metals without RBCs. Each of these steps is described in greater detail below.

RBCs were obtained from U.S. EPA Region 10 Supplemental Risk Assessment Guidance for Superfund (U.S. EPA 1991). The RBCs correspond to a cancer risk of 10^{-6} (10^{-7} for soil) or a hazard quotient (non-carcinogen) of 0.1. If both values were available for a particular chemical, the lower of the two values was used. Water RBCs were used for both surface water and groundwater data and soil RBCs were used for both soil and sediment data. The maximum concentration for each chemical in each medium was compared to the appropriate RBC. If the maximum concentration exceeded the RBC, the chemical was considered a COPC and was carried through the baseline human health risk assessment. For chemicals which were not detected at Kotzebue LRRS, an additional screening was performed to determine if the PQL exceeded the RBC. If the maximum PQL for a chemical in a particular medium exceeded the appropriate RBC, that chemical was added to the list of COPCs. Because the risk attributed to COPCs which were not detected above PQLs is less certain than risk attributed to detected COPCs, the two groups of chemicals were evaluated separately. If neither the maximum detected concentration or the maximum PQL exceeded the RBC, that chemical was not considered a COPC and was not evaluated further.

RBCs were not available for chemicals which did not have toxicity data (i.e., reference dose or slope factor). Organic chemicals in this category were also added to the list of COPCs if they were detected at Kotzebue LRRS. Exceptions to this rule were made for the TPH fractions (diesel and gasoline) because toxicity data for the weathered fuels typical of TPHs are not available. Human health risk due to hydrocarbons was assessed by characterizing the risk from the semi-volatile and volatile organic compounds which make up TPH. Metals in this category were added to the list of COPCs if they were detected at greater than three times (3X) the mean background concentration for a particular medium. Although these chemicals were considered to be COPCs, risk was not quantitated due to the lack of toxicity data. The list of COPCs for each medium is given in Table 5-1. A total of 89 COPCs were identified using the approach described above. Within each of the four media, the number of COPCs ranged from 45 for sediment to 71 for groundwater. The majority of the COPCs were never detected at Kotzebue LRRS above the PQLs (category 2 in Table 5-1). This is particularly true for surface water and groundwater, where only 7 chemicals in each medium were considered to be COPCs based on detected concentrations.

A list of Human Health COPCs for Kotzebue LRRS is provided in Table 5-1. Site-specific contaminant analytical results (including background characterization) for samples collected during the 1994 remedial

TABLE 5-1. CHEMICALS OF POTENTIAL CONCERN (COPC) BY MEDIA FOR THE BASELINE HUMAN HEALTH RISK ASSESSMENT, KOTZEBUE LRRS, ALASKA (Page 1 of 2)				
	Media			
Chemical	Sediment	Soil	Surface Water	Groundwater
Metals				
Antimony	2	2		
Arsenic	1	1	2	2
Beryllium	1	1		
Cadmium	2			
Lead	4	4		
Magnesium			4	
Manganese			1	1
Selenium	2			
Thallium	1	1		
Pesticides/PCBs				
4,4'-DDD	1	1		
4,4'-DDE	1	1		
4,4'-DDT	1	1		1
Aldrin	2	1	1	2
Arochlor 1016	2	2	2	2
Arochlor 1221	2	2	2	2
Arochlor 1232	2	2	2	2
Arochlor 1242	2	2	2	2
Arochlor 1248	2	2	2	2
Arochlor 1254	1	1	2	2
Arochlor 1260	1	1	2	2
Dieldrin	2	1	1	2
Endrin Aldehyde		3		
Heptachlor	2	1	1	
Heptachlor Epoxide	1	1	1	2
Toxaphene	2	2	2	2
alpha BHC	1	1	1	
beta BHC		1	1	
delta BHC	3	3	3	
Semi-volatile Organics				
1,2,4-Trichlorobenzene				2
1,4-Dichlorobenzene		2		2
2-Methylnaphthalene		3		3
2,2'-Oxybis (1-Chloropropane)	2	2	2	2
2,4,6-Trichlorophenol		2	2	2
2,4-Dichlorophenol				2
2,4-Dinitrophenol			2	2
2,4-Dinitrotoluene	2	1	2	2
2,6-Dinitrotoluene	2	1	2	2
2-Nitroaniline		1	2	2
2-Nitrophenol		3		
3,3'-Dichlorobenzidine	2	2	2	2
3-Nitroaniline	2	2	2	2
4-Chloroaniline				2
4-Nitroaniline	2	2	2	2
Acenaphthylene				3
Benzo(a)anthracene	2	1	2	2
Benzo(a)pyrene	2	1	2	2
Benzo(b)fluoranthene	2	1	2	2

TABLE 5-1. CHEMICALS OF POTENTIAL CONCERN (COPC) BY MEDIA FOR THE BASELINE HUMAN HEALTH RISK ASSESSMENT, KOTZEBUE LRRS, ALASKA (Page 2 of 2)

Chemical	Media			
	Sediment	Soil	Surface Water	Groundwater
Benzo(k)fluoranthene	2	2	2	2
Chrysene	2	1	2	2
Dibenzo(a,h)anthracene	2	2	2	2
Dibenzofuran				2
Hexachlorobenzene	2	2	2	2
Hexachlorobutadiene	2	2	2	2
Hexachlorocyclopentadiene				2
Hexachloroethane		2		2
Indeno(1,2,3-c,d)pyrene	2	2	2	2
Isophorone		2		
N-Nitrosodi-n-propylamine	2	2	2	2
N-Nitrosodiphenylamine		2		
Naphthalene				1
Nitrobenzene		2		2
Pentachlorophenol	2	2	2	2
Phenanthrene		3		3
bis(2-Chloroethyl) Ether	2	2	2	2
bis(2-Ethylhexyl) Phthalate		2		1
Volatile Organics				
1,1,2,2-Tetrachloroethane	2	2	2	2
1,1,2-Trichloroethane			2	2
1,1-Dichloroethene	2	2	2	2
1,2-Dichloroethane			2	2
1,2-Dichloropropane			2	2
2-Hexanone		3		
Benzene			2	1
Bromodichloromethane		2	2	2
Bromoform				2
Bromomethane			2	2
Carbon Disulfide				2
Carbon Tetrachloride		2	2	2
Chlorobenzene				2
Chloroform			2	1
Chloromethane				2
Dibromochloromethane				2
Methylene Chloride				2
Styrene				2
Tetrachloroethylene (pce)				2
Trichloroethylene (tce)				2
Vinyl Chloride	2	2	2	2
Xylenes, total				1
cis-1,3-Dichloropropene		2	2	2
trans-1,3-Dichloropropene		2	2	2

Key:
1 = Detected concentration exceeded screening value
2 = Practical Quantitation Limit (PQL) exceeded screening value
3 = No screening value available; chemical was detected
4 = No screening value available; metal detected > 3X mean background concentration

investigation are summarized by media and analytical method in Tables 4-12 through 4-21. All contaminant analytical results are summarized as site-specific maximum concentrations, and include all compounds detected in environmental samples collected during the 1994 remedial investigation at Kotzebue LRRS. A detailed description of IRP activities conducted at each site and area of concern investigated at Kotzebue LRRS is provided in Section 7.0, Summary of Site Status and Recommendations.

5.1.2.2 Chemicals of Potential Ecological Concern. A screening of the contaminant results was performed to determine which chemicals might pose a potential risk to ecological receptors (USAF 1995b). The screening was very similar to that performed for the human health baseline risk assessment (see Section 5.1.2.1). The screening consisted of the following four steps: 1) compare maximum detected concentration for each chemical in each medium with screening concentrations, 2) compare maximum PQLs to screening concentrations for chemicals which were not detected, 3) identify organic chemicals which were detected but for which no screening concentrations are available, and 4) compare maximum concentrations to mean background concentrations for metals without screening concentrations. Each of these steps is described in greater detail below.

Screening concentrations consisted of both surface water criteria and sediment quality guidelines, both of which are intended to be protective of aquatic organisms which are present in these media. Surface water quality criteria (the lower of the acute or chronic fresh water values) promulgated by U.S. EPA (1991d) were used to evaluate both surface water and groundwater contaminant concentrations at Kotzebue LRRS. Sediment quality guidelines were obtained from several sources, including *Adverse Effects to Benthic Organisms in Sediment* (Long and Morgan 1990), *Ontario Aquatic Sediment Quality Guidelines* (Persaud et al. 1993), and *Sediment Criteria for New York State* (Newell and Sinnott 1993). U.S. EPA sediment quality criteria were not used because lower (more conservative) values have been published in the above sources. For a given chemical, the lowest concentration from the above three sources was used as the screening concentration for both sediment and soil concentrations at Kotzebue LRRS. Sediment guidelines were used for soil concentrations because soil quality guidelines are not available. The maximum concentration for each chemical in each medium was compared to the appropriate screening concentration. If the maximum concentration exceeded the screening concentration, the chemical was considered a COPEC and was carried through the baseline ecological risk assessment. For chemicals which were not detected at Kotzebue LRRS, an additional screening was performed to determine if the PQL exceeded the screening concentration. If the maximum PQL for a chemical in a

particular medium exceeded the appropriate screening concentration, that chemical was added to the list of COPECs. Because the risk attributed to COPECs which were not detected is less certain than risk attributed to detected COPECs, the two groups of chemicals were evaluated separately. If neither the maximum detected concentration or the maximum PQL exceeded the screening concentration, that chemical was not considered a COPEC and was not evaluated further.

Screening concentrations were not available for approximately half the chemicals measured at Kotzebue LRRS. Organic chemicals in this category were added to the list of COPECs if they were detected at Kotzebue LRRS. Exceptions to this rule were made for the TPH fractions (diesel and gasoline) because toxicity data for the weathered fuels typical of TPHs are not available. Ecological risk due to hydrocarbons was assessed by characterizing the risk from the semi-volatile and volatile organic compounds which make up TPH. Metals in this category were added to the list of COPECs if they were detected at greater than 3X the mean background concentration for a particular medium. The list of COPECs for each medium is given in Table 5-2. A total of 67 COPECs were identified using the approach described above. Within each of the four media, the number of COPECs ranged from 28 for sediment to 41 for soil.

5.1.3 Contaminant Overview

This section provides a general discussion regarding inorganic and organic contaminant detection at Kotzebue LRRS.

5.1.3.1 Inorganics. Arsenic was detected at relatively low concentrations with the exception of a single background soil boring (at 800 mg/kg) collected at 10.5 ft below ground surface during the installation of the background monitoring well MW1 (see Table 4-15). The elevated detection of arsenic was not included in the mean background concentration calculation as the elevated detection was considered an outlier and was not representative of background surface soil conditions. In sediments, lead and zinc were identified as COPCs. Lead was detected at background criteria and zinc at elevated concentration in lake sediments at Site SS07 (see Table 4-15). Inorganic compounds detected in surface waters include barium, magnesium, and manganese (see Table 4-20). In groundwater, manganese was identified above background criteria relative to inorganic concentrations detected in a single background monitoring well installed at Kotzebue LRRS (see Table 4-20).

TABLE 5-2. CHEMICALS OF POTENTIAL ECOLOGICAL CONCERN (COPEC) BY MEDIA AT KOTZEBUE LRRS, ALASKA (Page 1 of 2)				
	Media			
Chemical	Sediment	Soil	Surface Water	Ground Water
Metals				
Antimony	2	1		
Barium			4	
Cadmium	2	2	2	2
Lead		1		
Magnesium			4	
Manganese			3	3
Mercury			1	1
Selenium			2	
Silver	1		2	2
Pesticides/PCBs				
4,4'-DDT	1		1	1
Arochlor 1016	2	2	2	2
Arochlor 1221			2	2
Arochlor 1232			2	2
Arochlor 1242			2	2
Arochlor 1248			2	2
Arochlor 1254			2	2
Arochlor 1260	1	1	2	2
Dieldrin	1	1	1	2
Endosulfan Sulfate			3	
Endrin	1	1	2	2
Endrin Aldehyde		3		
Heptachlor			1	2
Heptachlor Epoxide			1	2
Methoxychlor			2	2
Toxaphene	2	2	2	2
alpha-Chlordane			2	2
alpha BHC			3	
delta BHC			3	
gamma-Chlordane	1		2	2
Semi-volatile Organics				
2,4-Dichlorophenol		3		
2,4-Dintrotoluene		3		
2,6-Dinitrotoluene		3		
2-Methylnaphthalene	2	1		3
2-Nitroaniline		3		
2-Nitrophenol		3		
4-Methylphenol	3	3		3
4-Nitroaniline		3		
4-Nitrophenol		3		
Acenaphthylene				3
Anthracene	2	1		
Benzo(b)fluoranthene	2	1		
Benzo(g,h,i)perylene	2			
Benzo(k)fluoranthene	2	2		
Benzoic Acid	3	3		3

TABLE 5-2. CHEMICALS OF POTENTIAL ECOLOGICAL CONCERN (COPEC) BY MEDIA AT KOTZEBUE LRRS, ALASKA (Page 2 of 2)				
	Media			
Chemical	Sediment	Soil	Surface Water	Ground Water
Butylbenzylphthalate		3		
Dibenzo(a,h)anthracene	2	2		
Dibenzofuran		3		3
Diethyl Phthalate				2
Dimethylphthalate		3		
Fluorene	2	1		3
Hexachlorobutadiene	2			
Hexachlorocyclopentadiene			2	2
Isophorone		3		
Phenol		3		
di-n-butyl Phthalate		3		2
Volatile Organics				
1,1,2-Trichloro-1,2,2-trifluoroethane	3	3		
1,1-Dichloroethene	2	2		
2-Hexanone		3		
Acetone	3	3	3	3
Carbon Disulfide				3
Chloroform		3		
Ethylbenzene	3	3		
Methyl Ethyl Ketone (2-butanone)	3	3	3	3
Methylene Chloride	3	3	3	
Toluene	3	3		
Xylenes, total	3	3		3
cis-1,2-Dichloroethylene		3		

Key:
1 = Detected concentration exceeded screening value
2 = Practical Quantitation Limit (PQL) exceeded screening value
3 = No screening value available; chemical was detected
4 = No screening value available; metal detected > 3X mean background concentration

5.1.3.2 Organic Contaminants. Organic COPCs include all organic compounds screened from environmental samples collected during the 1994 RI (see Table 5-1). A discussion regarding organic contaminants detected at Kotzebue LRRS is provided in the following sections.

Petroleum Hydrocarbons--Petroleum hydrocarbon contamination linked to past installation operations and activities is the primary environmental problem identified at Kotzebue LRRS. Arctic-grade diesel is the primary source of detected concentrations of diesel range organics and BETX in site soils, surface waters and groundwater. Diesel fuel is a middle distillates of crude oil, containing about 8 percent n-alkanes, 22 percent iso-alkanes, 31 percent cycloparaffins, and 38 percent aromatic compounds that contain approximately 10 percent BETX and 10 percent polynuclear aromatic hydrocarbons (PAHs). Diesel blended for arctic use generally contains more low molecular weight hydrocarbons than does normal diesel fuel.

Aromatic hydrocarbons (such as BETX) were detected at relatively low concentrations in a limited number of soil, surface water, and groundwater samples collected at Kotzebue LRRS (see Tables 4-12 through 4-21). Benzene was detected in only two soil samples, at a maximum concentration in a sample of soil from the SS12-Spill No. 3 Site at a concentration of 1.6 mg/kg (see Table 4-12). The limited detections of aromatic hydrocarbons in Kotzebue LRRS soils likely results from the low percentage of these compounds in fuels used at the site, and from volatilization and biodegradation that has occurred since the time of release. Benzene was detected in a single groundwater sample (at an estimated concentration of 9.0 ug/L) collected from Site ST05-Beach Tanks.

Residual range organics were measured in selected soil samples to evaluate for the presence of heavier fraction hydrocarbons (i.e., C_{28} through C_{40}) associated with potential waste oil contamination. Residual range organics were detected at elevated concentrations at Sites SS15-Garage/Power Plant, SS02-Waste Accumulation Area No.2/Landfill, and AOC10-Septic Holding Tank (see Table 4-16).

Volatile Organic Compounds--Volatile organic compound analysis was conducted routinely to measure volatile organic compounds associated with petroleum hydrocarbon contamination, and to evaluate other potential contaminant sources (e.g., waste oils and solvents). The limited detection of aromatic hydrocarbons (such as BETX) in soil, surface water, and groundwater samples collected at Kotzebue LRRS are considered to be associated with arctic-grade diesel fuel contamination at the site. The

detection of other VOCs including cis-1,2-dichloroethene, trichlorothene, and tetrachloroethene indicates that other potential source(s) of VOCs contamination may be present. However, the detection of compounds such as trichloroethene were limited in extent and occurred at relatively low concentrations (see Tables 4-12 through 4-21).

Semivolatile Organic Compounds--The analysis of semivolatile organic compounds was routinely conducted to characterize a wide range of semivolatile compounds potentially present at Kotzebue LRRS sites. The primary source of petroleum hydrocarbons was related to middle-distillate fuels which contained approximately 10 weight percent polynuclear aromatic hydrocarbons. In addition to diesel fuel, waste oils and solvents formerly stored and used at the facility may be a source of SVOCs at some sites. SVOCs detected at Kotzebue LRRS are summarized in Tables 4-12 through 4-21. Naphthalene and 2-methylnaphthalene were the most commonly identified compounds in both soil and groundwater samples collected at the site.

Organochlorine Pesticides and PCBs--Organochlorine pesticides and PCBs were routinely analyzed for in samples collected during the 1994 RI. Pesticides were detected ubiquitously in site soils at Kotzebue LRRS, including all background surface soils sample locations. The pesticide 4,4'-DDT was detected at a maximum concentration of 5.3 mg/kg at Site SS11-Fuel Spill. Pesticides were detected in sediment at Site SS07-Lake, including 4,4'-DDD at 3.1 mg/kg. The pesticides 4,4'-DDT, 4,4'-DDD, and 4,4,'-DDE were detected at relatively low concentrations in surface water and near-beach groundwater at Site SS02 (see Table 4-19). There is no documented use of pesticides at the Kotzebue LRRS; however pesticides may have been used for insect control at the installation.

5.2 CONTAMINANT SOURCE IDENTIFICATION

The *IRP Handbook* specifies that if contamination is confirmed, the area of contamination shall be considered to be a source, and migration pathways and receptors shall be determined. The *IRP Handbook* also states that if there are multiple sites in proximity to one another such that it is not possible to determine the individual source or sources, the area of contamination shall be considered a source, and migration pathways and receptors shall be determined for the zone, rather than for individual sites. A total of 19 sites and five areas of concern have been investigated at Kotzebue LRRS. Contaminant source

characterization including the identification of source location and boundaries, estimates of source volume or amounts, identification of potentially hazardous constituents present in the source and their concentrations, and information regarding the time, duration and rate of hazardous constituent release from the source is provided on a site-specific basis in Section 7.0, Summary of Site Status and Recommendations.

5.3 POTENTIAL MIGRATION PATHWAYS

This section discusses potential contaminant migration pathways at Kotzebue LRRS including a general discussion regarding contaminant fate and transport in groundwater, surface water, and air routes. A detailed discussion describing migration pathways associated with contaminated sites at Kotzebue LRRS is provided in the Baseline Human Health and Ecological Risk Assessment Report (USAF 1995b). Table 5-3 provides the chemical characteristics associated with specific organic compounds detected at Kotzebue LRRS. The chemical characteristics presented in Table 5-3 include critical fate and transport data necessary to evaluate general contaminant behavior in the Kotzebue LRRS environment.

5.3.1 Air Pathway

Contaminant transport via the air pathway can occur as a result of the volatilization of organic compounds from site source areas, and from airborne particulates (i.e., dust) containing contaminants identified in site soils. VOCs related to petroleum hydrocarbon contamination, including BETX, have been detected at relatively low concentrations in site soils during the 1994 remedial investigations. BETX compounds are characterized by their relatively high vapor pressures, and are potentially very volatile in the environment. However, contaminant transport in air via the volatilization mechanism, and subsequent pulmonary uptake by potential receptors, is considered relatively low at Kotzebue LRRS for the following reasons:

- Diesel fuel is the primary source of petroleum hydrocarbon contamination at Kotzebue LRRS. Diesel fuel contains approximately 10 percent BETX compounds by weight. The limited number of detections and the low concentration of BETX compounds encountered in previously characterized soils at Kotzebue LRRS suggests that a significant percentage of volatile constituents have volatilized, photolyzed, biodegraded, and/or leached from soils since release.

TABLE 5-3. CHEMICAL CHARACTERISTICS OF ORGANIC COMPOUNDS DETECTED DURING 1994 REMEDIAL INVESTIGATION, KOTZEBUE LRRS, ALASKA					
	Chemical Characteristics				
Chemical Compound	Water Solubility (mg/L)	Vapor Pressure (mm Hg)	Henry's Law Constant (atm-m^3/mol)	K_{oc}[a] (mL/g)	K_{ow}[b]
Benzene	$1.75E^{+03}$	$9.52E^{+01}$	$5.59E^{-03}$	$8.30E^{+01}$	$1.32E^{+02}$
Toluene	$5.35E^{+02}$	$2.81E^{+01}$	$6.37E^{-03}$	$3.00E^{+02}$	$5.37E^{+02}$
Ethylbenzene	$1.52E^{+02}$	$7.00E^{+00}$	$6.43E^{-03}$	$1.10E^{+03}$	$1.41E^{+03}$
Total xylene	$1.98E^{+02}$	$1.00E^{+01}$	$7.04E^{-03}$	$2.40E^{+02}$	$1.82E^{+03}$
PCB Aroclor 1260	$3.10E^{-02}$	$7.70E^{-05}$	$1.07E^{-03}$	$5.30E^{+05}$	$1.10E^{+06}$
4,4'-DDD	$1.00E^{-01}$	$1.89E^{-06}$	$7.96E^{-06}$	$7.70E^{+05}$	$1.58E^{+06}$
4,4'-DDE	$4.00E^{-02}$	$6.50E^{-06}$	$6.80E^{-05}$	$4.40E^{+06}$	$1.00E^{+07}$
4,4'-DDT	$5.00E^{-03}$	$5.50E^{-06}$	$5.13E^{-04}$	$2.43E^{+05}$	$1.55E^{+06}$
Delta-BHC	$3.14E^{+01}$	$1.70E^{-05}$	$2.07E^{-07}$	$6.60E^{+03}$	$1.26E^{+04}$
2-Methylnaphthalene	$2.54E^{+01}$*	--	--	$8.50E^{+03}$*	$1.29E^{+04}$*

Source: U.S. EPA (1986). Superfund Public Health Evaluation Manual. Office of Emergency and Remedial Response, Washington, DC. EPA/540/1-86-060. *Taken from Ney, R.E. 1990.

[a] Adsorption coefficient.

[b] Octanal/water coefficient.

- Extreme climatic conditions limit the potential for volatilization at Kotzebue LRRS. Cold temperatures and frozen ground limits existing potential volatilization to approximately four months of the year. Additionally, precipitation in this region is greatest during the summer months, limiting the potential for volatilization of contaminants from source areas.

- High soil moisture content and near-surface permafrost characterizes the tundra hill and surrounding area. BETX compounds have relatively high water solubilities, and therefore may dissolve in surface water and active zone pore waters and subsequently diffuse from these waters at relatively slow rates. These conditions would tend to limit the potential for volatilization at sites located above the beach area.

In addition to volatilization, airborne particulates (dust) may provide a mechanism for contaminant transport via the air pathway at Kotzebue LRRS. The average wind speed for the Kotzebue area is relatively high (11 knots), with the prevailing wind direction from the east-southeast. However, the same climatic conditions that limit the volatilization of contaminants from soil (frozen conditions, summer rainfall, saturated tundra) also limit the potential for dust generation at the installation. Additionally, the installation is located approximately four miles south of the City of Kotzebue. It is extremely unlikely that the eolian transport of contaminated soils from the installation could impact the town of Kotzebue. The air migration pathway is discussed further and evaluated in the Kotzebue LRRS baseline risk assessment.

5.3.2 Surface Water Pathway

Kotzebue LRRS is situated atop a tundra hill located approximately 0.25 miles east of Kotzebue Sound. Most of the sites under investigation at Kotzebue LRRS range in elevation from 120 to 155 feet Mean Sea Level, with the exception of Site SS02 and Site ST05, both of which are located adjacent to Kotzebue Sound. Surface water runoff originating from the installation is topographically directed either west toward Kotzebue Sound, or east toward nearby wetlands. Runoff draining east could potentially reach the lake which served as the former installation's surface water supply. Table 5-4 presents surface water drainage features and directions for sites located at Kotzebue LRRS.

TABLE 5-4. HYDROGEOLOGIC CHARACTERISTICS SUM[illegible] FOR 1994 REMEDIAL INVESTIGATION, KOTZEBUE LRRS SITES

Site Identification	Maximum Sample Depth (ft BGS)	Depth to Frozen Ground (ft BGS)	Depth to Active Zone Water (ft BGS)	Surface Drainage Feature	Surface Drainage Direction	Estimated Active Zone Flow Direction	Soil Profile	
							Depth	Description
SS13-Landfarm (AOC1)	4.0	Not Encountered (>4.0)	Not Encountered	Moderate drainage	East-Northeast	Assumed Northeast	0.0 to 2.5 2.5 to 4.0	gravelly Sand fill/landfarm sandy Gravel fill (engineered fill) at 4.0 ft, tundra not encountered
AOC2-POL Line	3.5	1.5 to 3.5	Not Encountered to 1.5	Generally poor drainage, steep slope	West-Southwest	Assumed Southwest	0.0 to 3.5	gravelly Sand, well graded with some organic material present
SS14-East Tanks (AOC3)	3.0	3.0	1.5 to 2.0	Moderate drainage	East-Northeast	Assumed Northeast	0.0 to 4.0	silty sandy Gravel (fill), well graded
SS15-Garage/Power Plant (AOC4)	7.0	Not Encountered to 1.0 (Beneath Power Plant)	0.5 (Beneath Power Plant) to 7.0	Poor drainage, very slight slope	West-Southwest	Assumed Southwest	0.0-7.0	gravelly Sand (fill) varies from approximately 2.5 ft beneath the Power Plant to maximum thickness of 7.0 ft
AOC5-Small Day Tanks	3.5	1.2 to 4.7	0.5 to 3.2	Varies depending on location of Day Tank	Varies depending on location of Day Tank	Varies depending on location of Day Tank	Varies depending on location of Day Tank	Varies depending on location of Day Tank: typically gravelly Sand/sandy Gravel (fill)
SS16-Navigational Aid Bldgs. (AOC6)	3.0	1.0 to 3.8	Not Encountered to 2.5	Moderate to poor drainage	West-Southwest	Assumed Southwest	0.0 to 3.5 3.5 to 4.0 4.0 to 6.5	gravelly Sand (fill) Tundra mat Gray Silt
AOC7-Steel Pilings	1.0	1.0	0.75 to 1.0	Poor drainage	East-Northeast	Assumed Northeast	0.0 to 1.0	Black sandy Silt, high organic content
AOC8-White Alice Garage	3.5	1.0 to 2.5	Not Encountered to 1.2	Moderate drainage	West-Southwest	Assumed Southwest	0.0 ro 4.0 4.0 to 4.5 4.5 to 6.0	gravelly Sand (fill) Trundra mat Brown/gray Silt
ST04-White Alice Tanks (AOC9)	2.0	1.5 to 2.2	Not Encountered to 2.0	Poor drainage	West	Assumed West	0 to 5.0 5.0 to 5.5 5.5 to 6.5	gravelly Sand (fill) Tundra mat Gray Silt
AOC10-Septic Holding Tank	NA	NA	NA	NA	NA	NA	NA	NA
SS18-Truck Fill Stand (AOC11)	2.0	2.5 to 4.0	0.5 to 2.5	Generally poor drainage	South-Southwest	Assumed Southwest	0.0 to 5.0 5.0 to 5.5 5.5 to 6.5	gravelly Sand (fill) Tundra mat Gray Silt
SS19-PCB Spill South Fence (AOC12)	1.0	Not Encountered	Not Encountered	Moderate drainage	West-Southwest	Assumed Southwest	0.0 to 3.0	gravelly Sand (fill)
ST05-Beach Tanks	23.0	5.0 to >23	4.0 to 8.0	Good drainage	West	West	0.0-13.0 13.0-23.0	silty gravelly Sand sandy Silt/silty Clay
SS02-Waste Acc. Area No. 2/Landfill	1.0	Not Encountered (>6.7)	3.5 to 6.7	Good drainage	West	West	0.0-11.50	silty gravelly Sand
SS07-Lake	1.0	Not Encountered (>1.0)	Not Encountered	Moderate to poor drainage	North	North	0.0-1.0	Brown gravelly Sand
SS08-Barracks Pad	1.5	2.0	0.6 to 1.6	Poor drainage, very slight slope	East-Southeast	Assumed East-Southeast	0.0-3.0	gravelly Sand (fill)
SS12-Spills No. 2 and 3	7.5	0.5 to >7.0	0.25 to 7.0	Poor drainage, steep slope in tundra	West-Southwest	West-Southwest	0.0-7.5 0.0-2.0 0.0-1.75	Gravel fill Disturbed tundra Native tundra
SS11-Fuel Spill	1.0	0.5 to>1.0	0.5 to >1.0	Poor drainage, slight slope	East	Assumed East	0.0-1.0	Varies from Gravel to gravelly/sandy Silt to gray Silt

ft BGS = Feet below ground surface.

Melting of the annual snowpack usually occurs over a relatively short time period each year, referred to as break-up, and coincides with the greatest annual surface water flow at Kotzebue LRRS. The portion of the tundra surface not frozen and containing surface water is termed the active zone. Surface water infiltration rates have not been published for the Kotzebue area, but recharge to the tundra hill active zone is limited by the low average annual precipitation, extended periods of sub-freezing conditions, and the low intrinsic permeability of native soils.

Contaminant migration via surface water runoff at Kotzebue LRRS may result from contaminants sorbed onto entrained soil particles and/or from contaminants dissolved in rainwater or snowmelt. Organic compounds previously detected in site soils at Kotzebue LRRS include relatively mobile volatile aromatic hydrocarbons (e.g., BETX), and compounds that are generally much less volatile and mobile, such as pesticides and PCBs. Volatile compounds such as BETX are characterized by relatively high vapor pressures and water solubilities. BETX compounds generally volatilize readily in the surface environment due to their relatively high vapor pressures; however, they can also dissolve readily in surface and pore waters due to their high water solubilities, and may actually diffuse more slowly than less-soluble alkanes and alkenes (Baehr 1987). In general, petroleum hydrocarbons are readily photolizable, are readily metabolized by microorganisms (biodegraded), and do not tend to bioaccumulate in the environment.

Pesticides and PCBs are characterized by relatively very low water solubilities and vapor pressures, and do not tend to volatilize at the surface or to readily leach into surface or pore waters. These compounds tend to adsorb to soil particles, as indicated by their high adsorption coefficients (Koc). Thus, the surface water transport of PCB compounds, and to a lesser degree pesticides, are restricted to contaminants adsorbed to soil particles. The relatively high TOC concentrations identified in native soils at Kotzebue LRRS will act to bind PCB compounds and limit the potential for surface water transport. Pesticides and PCBs have a strong affinity to bioaccumulate in the environment, indicated by their relatively high octanol/water coefficients (Kow). These compounds do not readily biodegrade, but are susceptible to phototransformation (e.g., photolysis). The surface water migration pathway is evaluated in the Kotzebue LRRS baseline risk assessment.

5.3.3 Groundwater Pathway

Groundwater associated with the beach area at Kotzebue LRRS is restricted to a narrow zone adjacent to Kotzebue Sound, where the depth to permafrost is sufficiently depressed by marine influence to support

a continuously saturated subsurface zone. The thickness of the near-beach aquifer system is estimated at approximately 7 to 9 feet based on a competent silty clay confining layer identified at the Beach Tanks Site. The top of the confining layer was identified at approximately 13 feet below ground surface and has a thickness greater than 10 feet based on borings installed at Site ST05. The confining layer is suspected to be a blue clay marine deposit approximately 60 feet in thickness (Cederstrom 1961). Frozen ground was encountered in some borings at varying depths (e.g., minimum depth encountered approximately 6 feet below ground surface (BGS) during the installation of monitoring wells at Kotzebue LRRS beach area.

Near-beach groundwater typically occurs between 3 and 4 feet BGS along the steepened beach face immediately adjacent to Kotzebue Sound, and from 6 to 7 feet BGS within the beach tank pads, based on data obtained from monitoring wells installed during the 1994 RI. The local groundwater flow direction is estimated to be to the southwest, toward Kotzebue Sound. Hydraulic gradients calculated at high tide on 24 July 1994 and low tide on 25 July 1994 fluctuate from 0.0032 feet per feet to 0.0049 feet per feet, respectively along the sample flowpath.

Physical parameters for the subsoil materials housing the near-beach aquifer that were measured during the 1994 RI include permeability and grain-size distribution (see Section 4.4.7, Geotechnical Assessment). Hydraulic conductivity was estimated by conducting falling-head and rising-head slug tests and using estimates from constant-head permeability tests and grain-size analyses. The average horizontal hydraulic conductivity from wells ST0MW4-MW5-and MW6 is estimated at 2.88 feet per day based on rising-head slug test results (see Section 4.6.2, Slug Test Results). Soil permeability tests conducted on beach soils provides an estimated average vertical hydraulic conductivity of 0.57 feet per day. Grain-size distribution results indicate that beach soils/sediments range from well-graded sandy gravels to poorly graded gravelly sand.

The mean tidal range is 2.1 ft at the nearest location where tidal corrections have been established (Kiwalik, Kotzebue Sound); the diurnal tidal range at Kiwalik is 2.7 ft (NOAA 1990). Tidal influences on the near-beach aquifer system can directly affect aquifer gradients and geochemistry, influencing contaminant migration and impacting an evaluation of remedial alternatives. Tidal monitoring and static water level measurements collected during the 1994 remedial investigation indicated that tidal fluctuation in Kotzebue Sound clearly impacts the near-beach aquifer in the vicinity of Kotzebue LRRS. However,

based on the limited vertical extent of the water table aquifer and the observed tidal fluctuation, it is unlikely that the tidal cycles have a significant effect on groundwater migration to the Sound (see Section 4.6.3, Tidal Monitoring Results). Recharge of the near-beach aquifer system has not been addressed by previous studies. Recharge of the beach aquifer is likely controlled by the highly seasonal nature of active zone (suprapermafrost water) inputs that recharge the beach area from the tundra uplands. Kotzebue Sound tidal influence on the system, together with the seasonal nature of freshwater recharge, may result in some seasonal changes with respect to salinity and geochemistry; hydraulic gradients may also be slightly affected. Geochemical results indicate that mixing of seawater occurs in the fore-beach area at Kotzebue LRRS (see Section 4.6.6, Natural Attenuation Assessment Results).

Natural attenuation processes (including biodegradation) are suggested to be active in the near-beach aquifer system at Kotzebue LRRS. However, the rate of contaminant degradation in groundwater is effected by low groundwater temperatures and lack of basic nutrients which limit the potential growth of indigenous microorganisms identified as capable of metabolizing petroleum hydrocarbons (see Section 4.6.6, Natural Attenuation Assessment Results).

5.3.3.1 Hydrogeologic Summary. This section briefly describes the hydrostratigraphy and geology of the beach environment at Kotzebue LRRS based on data obtained during the drilling of boreholes and from wells installed within the Kotzebue LRRS beach area. Figure 5-1 identifies groundwater monitoring well locations, provides reference to hydrogeologic cross sections (A-A' and B-B'), and provides a typical geological sequence for Beach Sites SS02 and ST05. Figure 5-2 provides a longitudinal hydrogeologic cross section (A-A') of the near-beach environment between Site ST05 and Kotzebue Sound. Figure 5-3 provides a transverse hydrogeologic cross section (B-B') describing the fore-beach to back-beach area at Site ST05.

The shallow near-beach aquifer system at Kotzebue LRRS consists of unconsolidated sediments approximately 13 feet thick. The upper portion of the water table aquifer (approximately 0-5.0 feet below ground surface) is typically comprised of gravelly Sand/sandy Gravel beach terrace deposits. The base of the water table aquifer is defined by a competent confining layer at approximately 13 feet below grade. The top of the confining bed consists of a massive clay with minor silt toward the base of the bluffs; silt content varies somewhat, but doesn't appear to include much more than 50% silt in locations drilled along the back-beach area. The confining layer reveals increased silt content toward Kotzebue Sound. Soil boring ST05-SB19 was advanced to 23.5 feet below ground surface to establish the thickness of the

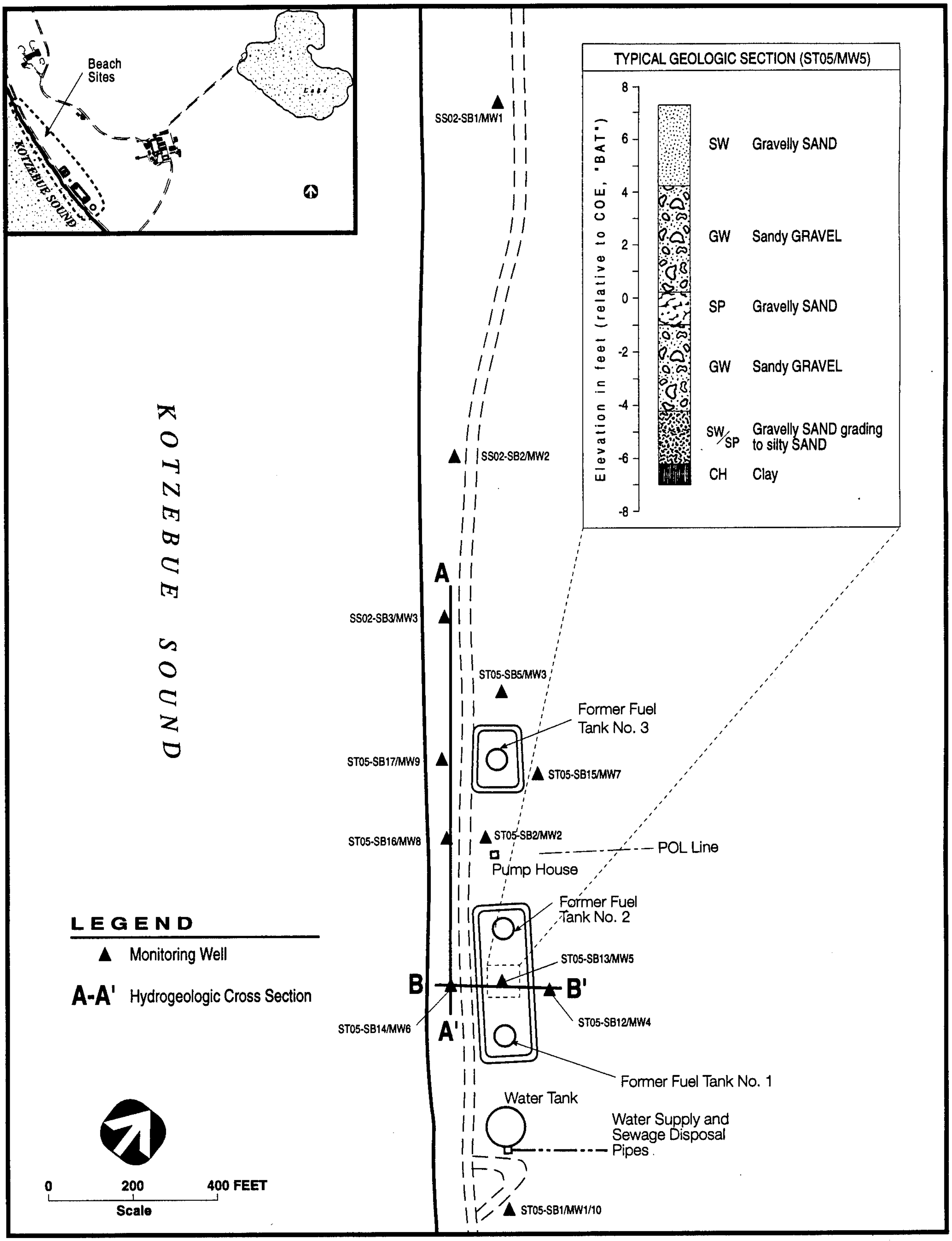

Figure 5-1. Groundwater Monitoring Well Locations, Typical Geologic Section, and Hydrogeologic Cross Section Reference (A-A' and B-B') at Beach Sites SS02 and ST05, 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

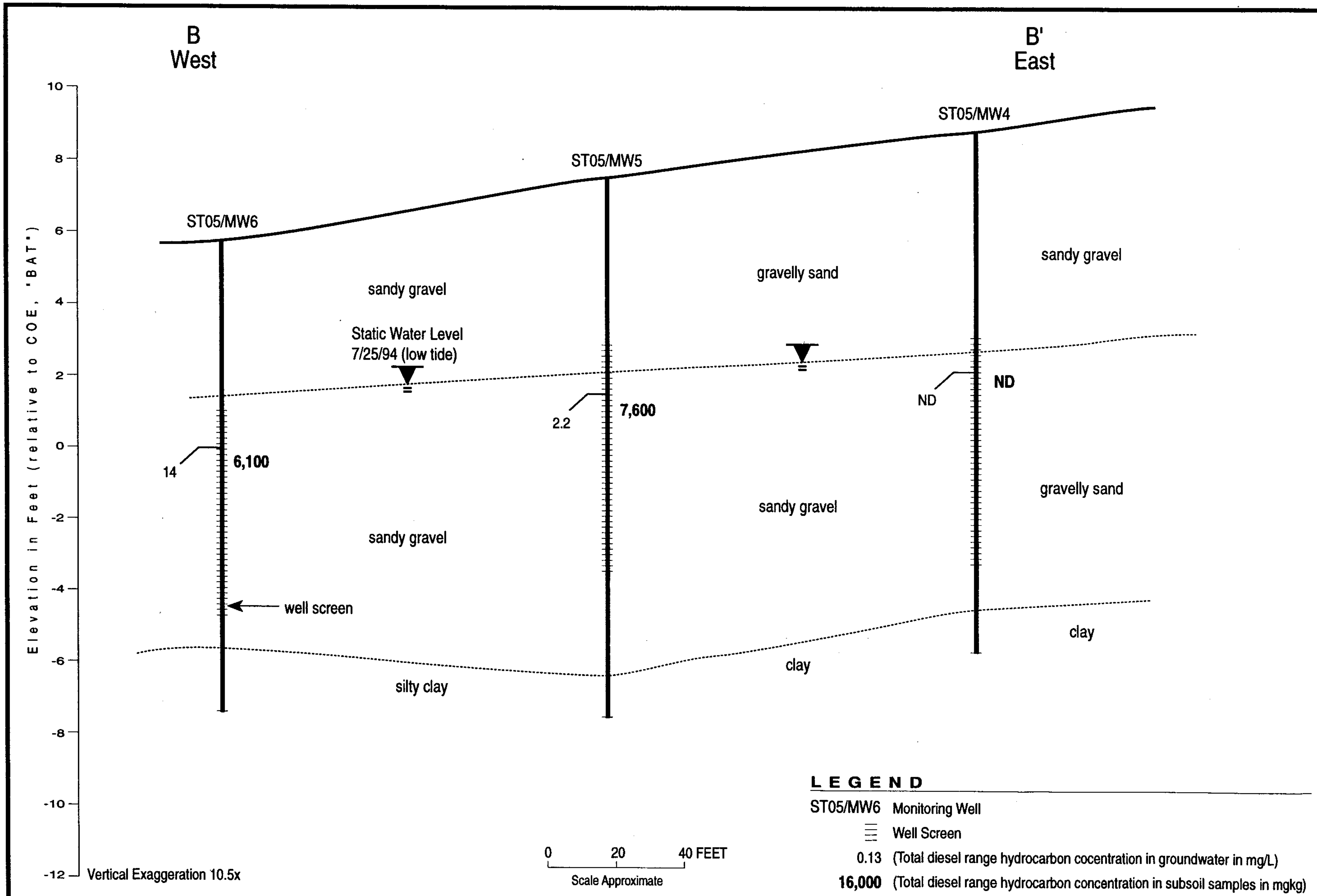

Figure 5-2. Hydrogeologic Cross Section B-B' at Site ST05, 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

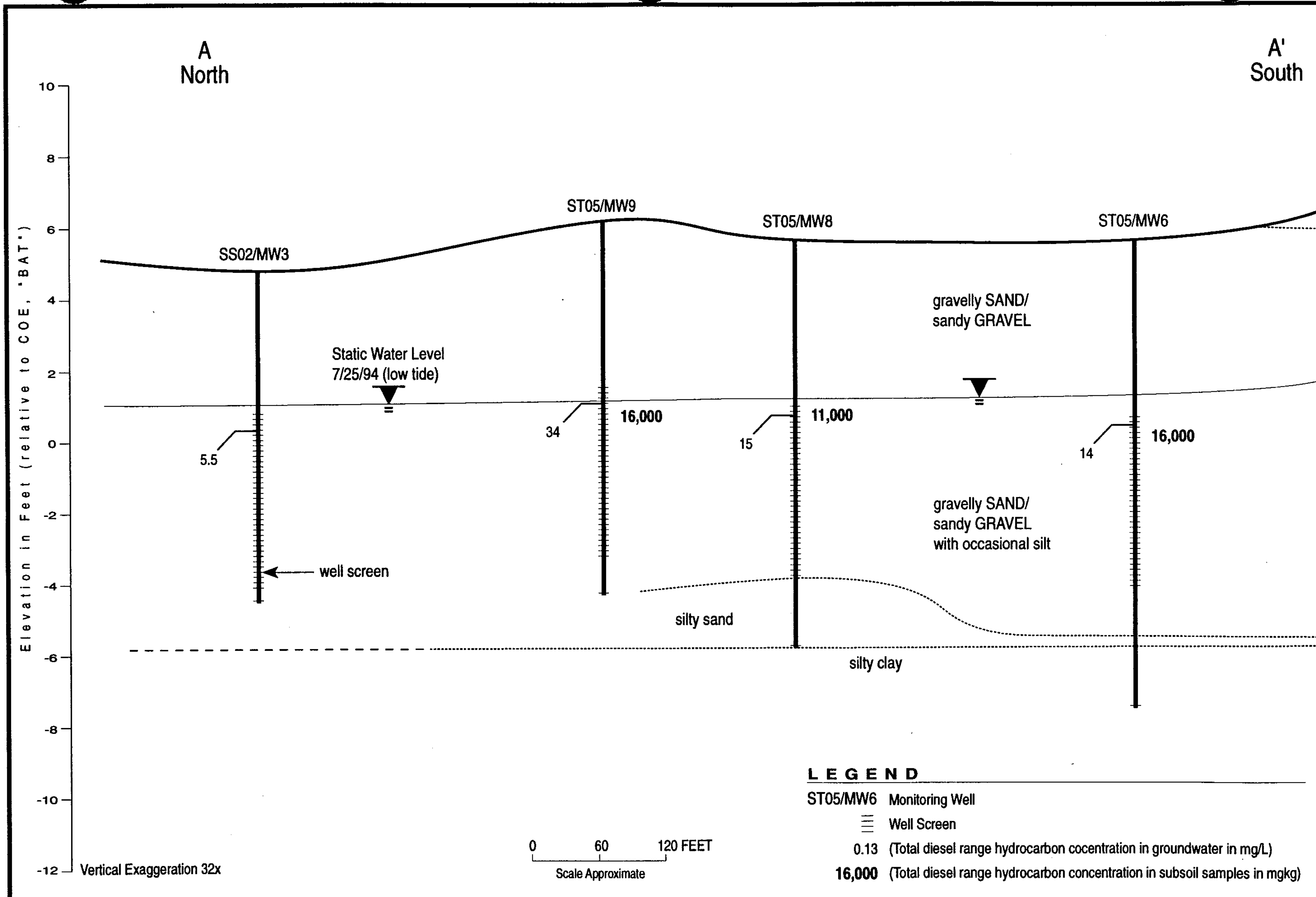

Figure 5-3. Hydrogeologic Cross Section A-A' at Site ST05, 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

confining bed (see Appendix A). Gravelly, silty, clay (massive) was characterized from 13 to 16 feet below ground surface. The massive clay graded to sandy silt at approximately 17 feet below ground surface and continued to the base of the boring at 23.5 feet below ground surface.

A sequence of graded storm deposits is present between the upper gravel terrace deposits and lower bounding silt/clay, which serves as a confining layer for shallow contamination. These storm deposits resemble overbank deposits because they exhibit grading of virtually all beds, fining upward sequences with organic rich layers between storm surge sequences, which have gravels at their bases. Shell fragments and wood debris are common, the latter present in the organic layers.

5.4 POTENTIAL RECEPTORS

The section discusses potential human and ecological receptors associated with Kotzebue LRRS and evaluates potential exposure for both human health and ecological pathways. Demographics and biological habitats associated with Kotzebue LRRS are summarized in Section 2.0, Environmental Setting. A detailed evaluation of potential receptors and associated exposure pathways is provided in the Baseline Human Health and Ecological Risk Assessment Report (USAF 1995b).

5.4.1 Potential Human Receptors

Several population groups represent potentially exposed human receptors for the Kotzebue LRRS, including:

- Radar maintenance technician(s)
- Recreational users
- Subsistence users

A single radar technician (housed in the City of Kotzebue) maintains the active radar dome facility at Kotzebue LRRS. In addition, USAF personnel and radar maintenance technicians may service the installation on a periodic basis. Potential recreational users (adults and children) include: ATV use on roads and beach areas, beach combing and summer picnicking along beach areas, and recreational hunting and fishing. Subsistence use by adults and children may include berry picking in adjacent wetlands, terrestrial hunting along the tundra hill and surrounding area, and marine hunting and fishing in Kotzebue

Sound and along the beach area. Figure 5-4 identifies human health exposure pathways evaluated for Kotzebue LRRS, Alaska.

5.4.2 Potential Ecological Receptors

Natural resources associated with the Kotzebue LRRS and surrounding area are limited by severe climate, short growing seasons, and poor soil conditions associated with permafrost and tundra environments. The following sections provide a general description of native vegetation, fish and wildlife, and threatened or endangered species associated with the Kotzebue area. Figure 5-5 identifies ecological exposure pathways evaluated for Kotzebue LRRS.

5.4.2.1 Vegetation. Moist tundra vegetation surrounds Kotzebue LRRS. Cottongrass tussocks and dwarf shrubs completely covers the ground in most areas. Soils are commonly saturated, and mosses and lichens grow in channels between tussocks (USAF 1993). Frost action creates small frost polygons supporting grass and forbs in many areas. Commonly occurring plants at Kotzebue LRRS include dwarf birch, labrador tea, mountain avens, bistort, and saxifrages. The moist tundra in the Kotzebue area is very sensitive to damage, and the natural revegetation and recovery of disturbed plant communities can take many years or decades (USAF 1993).

5.4.2.2 Fish. A variety of fish inhabit the inland and coastal waters of the Kotzebue area. All five species of Pacific salmon are found in Kotzebue Sound, but only chum salmon occur in substantial numbers (Kessler 1985). Other anadromous species important to subsistence fishing in the area include whitefish, nine-spined stickleback, and arctic char (Kessler 1985). Marine species found in the area include tomcod, Arctic cod, rainbow smelt, flounder, and herring (Kessler 1985; USDA 1979). Important freshwater species include grayling, pike, and sheefish (USAF 1993).

5.4.2.3 Terrestrial Mammals. Terrestrial mammals inhabiting moist tundra habitats include several species of vole, tundra shrew, lemming, tundra hare, Arctic ground squirrel, caribou, and red fox. Larger species such as brown and grizzly bear, wolf and moose also inhabit this environment, but do not typically range onto the Baldwin Peninsula (USAF 1993).

5.4.2.4 Marine Mammals. Whales such as bowhead, gray, killer, and beluga, reside in the Kotzebue area. Several seal species also inhabit the area and are harvested by the local native community, as are walrus (USAF 1993).

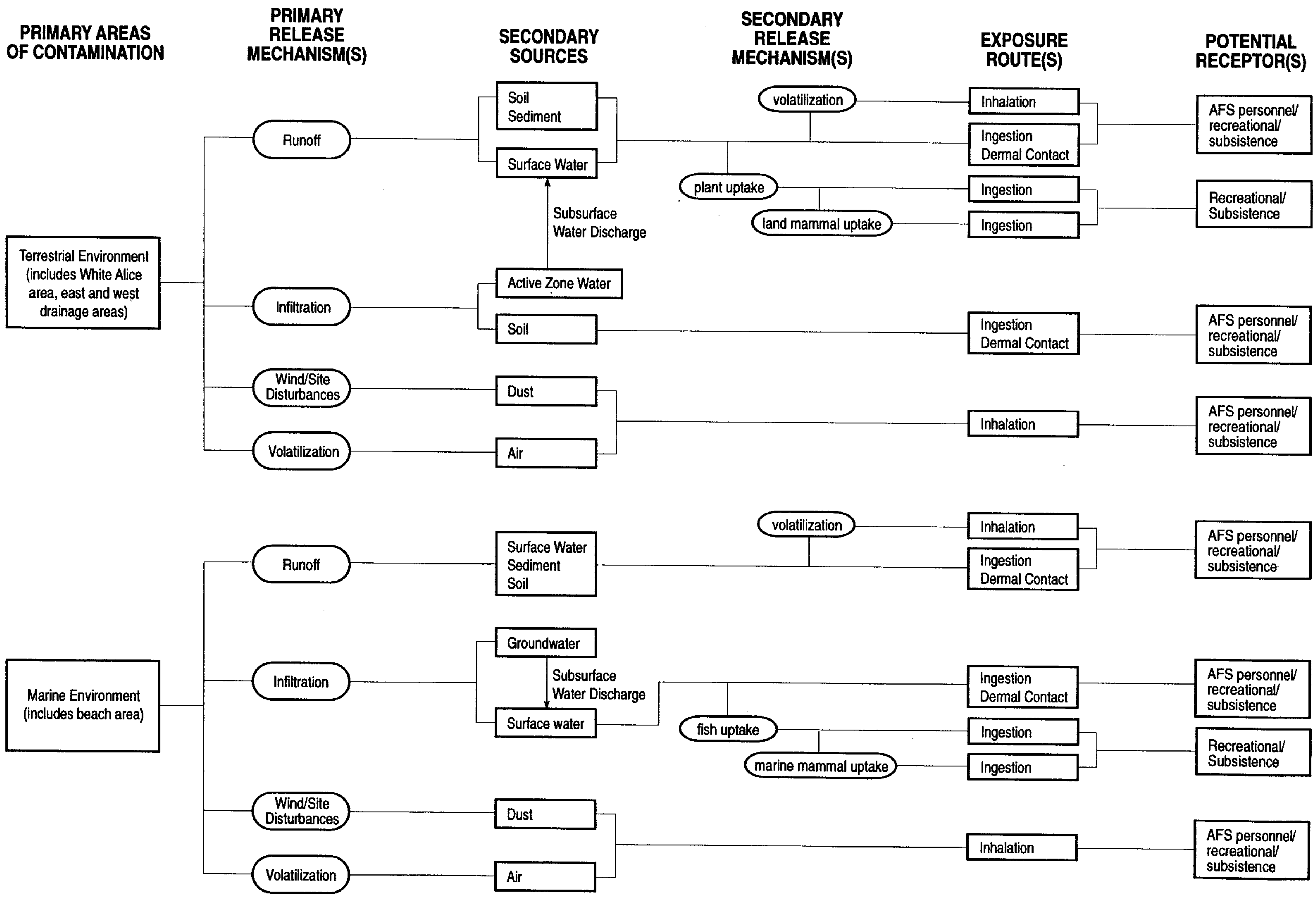

Figure 5-4. Human Health Exposure Pathways Evaluated for Kotzebue LRRS, Alaska.

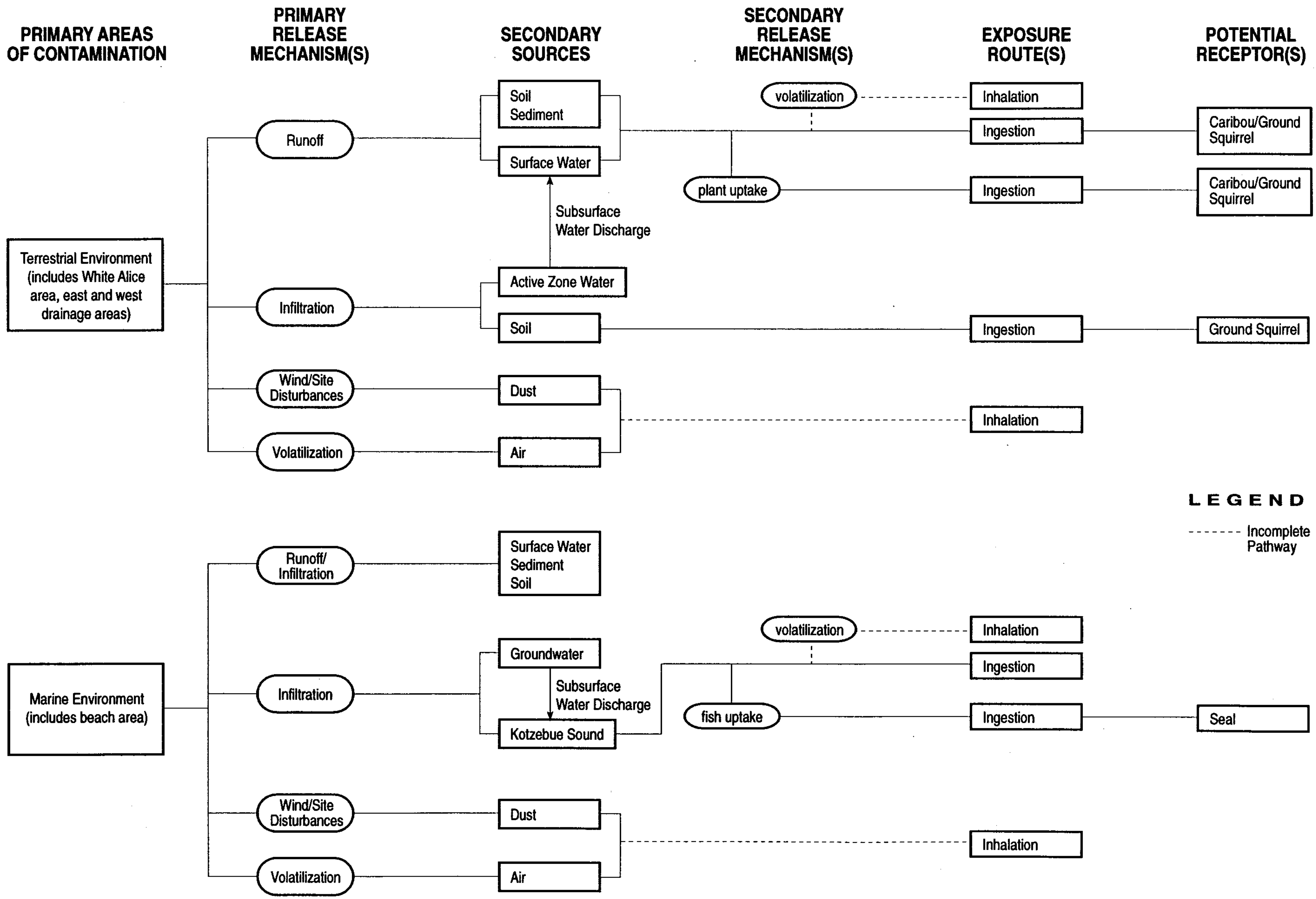

Figure 5-5. Ecological Exposure Pathways Evaluated for Kotzebue LRRS, Alaska.

5.4.2.5 Birds. The moist tundra environment is an important foraging area for many birds during the summer, when migrating species visit the region. The area also provides breeding and foraging habitat for waterfowl and shorebirds. The most common seabird species, found in the area include the long-tailed jaeger, common murre, arctic tern, and glaucous gull (USAF 1993).

5.4.2.6 Threatened or Endangered Species. No threatened or endangered species are known to occur at Kotzebue LRRS. However, peregrine falcons have been noted along the major drainages in the region, and thus may occasionally range onto the installation (USAF 1993).

5.5 HUMAN HEALTH AND ECOLOGICAL BASELINE RISK ASSESSMENT

A baseline risk assessment was conducted for Kotzebue LRRS to provide an estimate of the potential risk to human health and ecological receptors associated with various exposure scenarios involving site contaminants in the absence of remediation. The Baseline Human Health and Ecological Risk Assessment Report prepared for Kotzebue LRRS is based on the results of the 1994 RI, and serves as a supporting document to this RI/FS Report (USAF 1995b).

The human health risk assessment is intended to provide a quantitative assessment of the risk to humans from exposure to contaminants measured in soil, sediment surface water, and groundwater during the RI at the Kotzebue LRRS conducted in 1994. The risks enumerated in the baseline human health assessment are based upon two types of data: 1) actual measurements of contaminants in the sampled media, and 2) extrapolated estimates of contaminant concentrations into media which were not part of the sampling design, including: air, plants, and land and marine mammals. Extrapolated concentrations were based upon actual detected concentrations in either soil or water at the Kotzebue LRRS site and conservative estimates for exposure assumptions (USAF 1995b).

An ecological assessment is incorporated in the baseline risk assessment to evaluate the potential adverse effects of detected contaminants to species known to inhabit the study area. The baseline ecological risk assessment conducted for Kotzebue LRRS involves five tasks, including: 1) data evaluation and stressor characterization; 2) ecological characterization and selection of key receptor species; 3) toxicity assessment; 4) exposure assessment; and 5) risk characterization. The ecological assessment performed for Kotzebue LRRS focuses on estimating potential risks to individuals of identified target or indicator

species, and does not incorporate biological diversity or population studies (USAF 1995b). The results of the baseline risk assessment may be used to: 1) support a "No Further Action" decision, 2) prioritize the needs for remediation at various sites, or 3) provide a basis for the quantification of remedial objectives.

6.0 FEASIBILITY STUDY

A primary objective of a feasibility study (FS) is to develop an appropriate range of waste management and remediation options that can be fully analyzed using the evaluation criteria established in the National Contingency Plan. Feasibility studies are generally conducted in two phases. The first phase is the development and screening of remedial alternatives. During this phase, potential waste treatment technologies and containment/disposal requirements are identified. Technologies are then screened for applicability and assembled into remedial alternatives. The alternatives are screened as necessary to reduce the number subject to detailed analysis, preserving an appropriate range of options. Action-specific ARARs are then identified.

The second phase of an FS involves a detailed analysis of alternatives. During this phase, remedial alternatives are further refined as necessary, taking into consideration information collected during the RI. Alternatives are evaluated using the following nine criteria: 1) overall protection of human health and the environment, 2) compliance with ARARs, 3) long-term effectiveness and permanence, 4) reduction of toxicity, mobility, and volume through treatment, 5) short-term effectiveness, 6) implementability, 7) cost, 8 state acceptance, and 9) community acceptance. Once the remedial alternatives are compared against these criteria, they are compared against each other. This comparison leads to a remedy selection, a Record of Decision (ROD), detailed remedial design, and remedial action.

6.1 REMEDIAL ACTION OBJECTIVES

Remedial action objectives are environmental medium-specific goals for protecting human health and the environment. Preliminary remediation goals are established from readily available information such as ARARs (primarily the chemical-specific ARARs), reference doses, and risk-specific doses. This section discusses the development of remediation goals and objectives for Kotzebue LRRS.

6.1.1 Development of Remediation Goals

Remedial action objectives are site cleanup goals designed to address the identified nature and extent of contamination. They are expressed as meeting either ARARs or other site-specific human health and environmental protection standards. In general, the objectives should be as specific as possible, but without unduly limiting the range of alternatives that can be developed (EPA 1988).

Contaminant-specific ARARs are utilized to form the basis of site objectives unless they are not available (as for human exposure to contaminated soil at the site), or they are not adequately protective (as in a case where multiple contaminants pose a cumulative risk not adequately protected by the ARAR). Site-specific human health and environmental protection standards are used in these instances where ARARs are not appropriate. The protection standards are primarily the risk-specific doses and reference doses established in the toxicity assessment of the baseline risk assessment. ARARs that pertain to Kotzebue LRRS are discussed in Section 4.2.

General remedial action objectives for Kotzebue LRRS are presented in Table 6-1. They are presented by environmental media in terms of objectives for both human health and environmental protection. Also identified are potential exposure routes and receptors. Routes and receptors are identified because remedial actions to be considered include those that will reduce exposure by means other than reducing contaminant levels. Compiling the information by environmental media facilitates the consideration of remedial action objectives that protect a resource, such as clean air or surface water. Section 5.0, Site Conceptual Model, provides a detailed discussion regarding affected media and potential exposure routes and receptors at Kotzebue LRRS. The general objectives for remedial action at Kotzebue LRRS are further discussed in the following sections.

6.1.1.1 Soils/Sediment. Three primary lithologies characterize Kotzebue LRRS: beach sands and gravels, native soils associated with the tundra hill and surrounding area, and fill material used for roads and facility foundations. Specific remedial action objectives will include the following considerations:

- **Native Tundra**: An integral aspect to each remedial action objective is to minimize the negative impact of the remedial response itself. It is conceivable that a remediation activity could cause more threat to human health or the environment than it would remedy. Due to the fragile nature of the native tundra environment at Kotzebue LRRS,

TABLE 6-1. GENERAL REMEDIAL ACTION OBJECTIVES FOR KOTZEBUE LRRS, ALASKA

Environmental Media	Exposure Route	Receptors	Remedial Action Objectives: For Human Health	Remedial Action Objectives: For Environmental Protection
Soils/Sediment	Dermal Contact Ingestion Inhalation	USAF personnel Recreational use Subsistence use Ecosystem	Prevent exposure to soils exceeding contaminant-specific ARARs or site-specific protection standards.	Prevent migration of contaminants to the near-beach aquifer and to surrounding surface soils and surface waters. Minimize physical impact and stress to sensitive areas (e.g., native tundra) during remediation activities.
Surface Water[a]	Dermal Contact Ingestion Inhalation	USAF personnel Recreational use Subsistence use Ecosystem	Prevent exposure to surface water exceeding contaminant-specific ARARs or site-specific protection standards.	Prevent migration of contaminants to near-beach aquifer, surrounding surface soils, and adjacent surface waters.
Near-Beach Groundwater[b]	Inhalation Dermal Contact	USAF personnel Recreational use Subsistence use Ecosystem	Prevent exposure to groundwater exceeding contaminant-specific ARARs or site-specific protection standards.	Prevent migration of groundwater contamination at levels that could negatively impact Kotzebue Sound.
Air	Ingestion (Dust) Inhalation	USAF personnel Recreational use Subsistence use Ecosystem	Prevent exposure to airborne contaminants exceeding contaminant-specific ARARs or site-specific protection standards.	Prevent wind suspension of contaminated soil.

[a] Surface water sampling results and risk assessed health effects are very low for this media. Remedial action objectives may be met through achieving the objectives for soils and sediments.

[b] Potable water for Kotzebue LRRS is supplied by the City of Kotzebue. Groundwater at Kotzebue LRRS is limited and its development is restricted by climatic conditions, and therefore ingestion was not considered a significant exposure route.

remedial actions that do not cause damage to tundra and underlying permafrost will be favored.

- **Fill Material:** Fourteen gravel fill material source areas with DRO contamination migration potential have been identified. Estimated source volumes range from 16 to 11,111 cubic yards, with an estimated total source volume of 16,000 cubic yards. Remedial actions will focus on the isolation and/or removal of the source areas defined on a site-by-site basis in Section 7.0, Summary of Site Status and Recommendations.

- **Beach Sands and Gravel:** Elevated concentrations of DRO have been detected in beach sands and gravels and in shallow groundwater associated with Site ST05-Beach Tanks. An estimate of petroleum hydrocarbon contaminated soil with concentrations exceeding 1,000 mg/kg has been calculated at 48,000 cubic yards. Remedial action alternatives that limit disruption of the beach and avoid a potential increase of downward contaminant migration to the shallow groundwater system will be favored.

A general remedial action objective for soils and sediments at Kotzebue LRRS includes the removal and treatment, or containment, of contaminated soils as necessary to restore the site to a condition commensurate with its present and potential future uses.

6.1.1.2 Surface Water. Very low concentrations of semivolatile organics, pesticides, and metals were detected during the RI, as shown in Tables 4-17 through 4-21. DROs exceeded water quality criteria for several areas of ponded water adjacent to contaminated sites, however, no VOCs, SVOCs, or DROs were detected in the primary surface water bodies of Kotzebue Sound and the water supply lake. Risk assessed health effects from surface water were very low for human health and only manganese was identified as a chemical of potential ecological concern. Based upon these findings, specific surface water remediation alternatives are not warranted. Remedial action objectives for surface water may be met by achieving the remediation goals for soils and sediments.

6.1.1.3 Near-Beach Groundwater. Elevated concentrations of DRO have been detected in the shallow near-beach groundwater associated with Site ST05. Concentrations range from nondetect to a maximum of 34 mg/L (see Section 7.5, Site ST05-Beach Tanks). Because of climatic constraints and the limited

extent of groundwater contamination, only limited action remedial alternatives or those alternatives that remediate both soil and groundwater contamination simultaneously will be considered. Source control of soil contamination should greatly improve groundwater quality.

6.1.1.4 Air. Based on previous IRP investigation information and findings in this RI, exposure to airborne contamination is not expected to be a significant problem at Kotzebue LRRS. Benzene has been detected in soil at a depth of 7.0 ft below ground surface, but not in surface samples. Methylene chloride and chloroform were also detected, but their presence is suspect and likely attributed to laboratory contamination. Therefore, a remedial action objective to minimize the dispersion of potentially contaminated soil (dust) and vapors during the implementation of any response actions remains a priority, mainly with regard to personnel working at the site. Down-wind dispersion precludes any potential conditions that could affect human health, but air monitoring should be performed during remediation activities.

6.2 GENERAL RESPONSE ACTIONS

General response actions describe those actions that will satisfy the remedial action objectives. This section discusses general response actions for applicable environmental media at Kotzebue LRRS. Table 6-2 presents general response actions and associated remedial technologies to address contaminated soils, sediments, surface water, and near-beach groundwater at Kotzebue LRRS.

6.2.1 Applicable Media Areas/Volumes

Section 7.0, Summary of Site Status and Recommendations, provides a site-specific evaluation of those sites and areas of concern currently representing potential contaminant source areas (areas where contamination has been confirmed based on investigatory results). Section 7.0 includes source area identification and source characteristics data as applicable to individual sites and areas of concern. The soil target level used to establish the areal extent and volume of diesel range organics contaminant source areas at Kotzebue LRRS is 1,000 mg/kg (see Section 4.2, Applicable or Relevant and Appropriate Requirements).

TABLE 6-2. GENERAL RESPONSE ACTIONS AND ASSOCIATED TECHNOLOGIES TO ADDRESS CONTAMINATED SOIL, GROUNDWATER, AND SURFACE WATER AT KOTZEBUE LRRS, ALASKA		
General Response Action	Remedial Technologies for Soil	Remedial Technologies for Groundwater/Surface Water
NO ACTION	Consideration is required by the NCP	Consideration is required by the NCP
LIMITED ACTION	- Site controls - Institutional controls - Natural attenuation - Long-term monitoring	- Site control - Institutional controls - Natural attenuation - Long-term monitoring
CONTAINMENT	- Capping - Surface controls	
EXTRACTION	- Excavation	
EX SITU TREATMENT	PHYSICAL/CHEMICAL TREATMENT - Soil washing - Solidification/stabilization/fixation - Hot air vapor extraction BIOLOGICAL TREATMENT - Landfarming - Enhanced biodegradation - Slurry-phase biodegradation THERMAL TREATMENT - Low temperature thermal stripping - High temperature thermal treatment	
IN SITU TREATMENT	PHYSICAL/CHEMICAL TREATMENT - Vacuum vapor extraction - Soil flushing - Chemical reduction/oxidation - Fixation BIOLOGICAL TREATMENT - Enhanced biodegradation - Bioventing THERMAL TREATMENT - Thermally enhanced soil vapor extraction	BIOLOGICAL TREATMENT - Enhanced Biodegradation
OFFSITE TREATMENT	- Landfill - Incineration - Beneficial Reuse	

6.2.2 General Response Actions for Soils/Sediment

General response actions potentially capable of meeting the remedial action objectives for contaminated soils at Kotzebue LRRS include no action, limited action, containment, excavation and treatment, off-site treatment, and *in situ* treatment (see Table 6-2).

The No Action Alternative is required for consideration by the NCP. Limited action can range from simply restricting site access to long-term monitoring to detect changes in site conditions. Monitoring actions themselves do not achieve a specific cleanup goal, but can provide assurance that existing site conditions (on which no action/actions may be based) do no change substantially, and are considered adjunct technologies to support limited actions such as natural attenuation. Containment actions represent a variety of approaches to separate, or place a barrier between, contaminated soil and potential human or environmental receptors. Responses involving treatment can either be of the type where soil is excavated for treatment (*ex situ*) or left in place (*in situ*) for treatment. The excavation and treatment response can also include scenarios in which treatment is performed onsite and residue is disposed on- or off-site, or may include both off-site treatment and off-site disposal.

6.2.3 General Response Actions for Groundwater and Surface Water

The general response actions that may be capable of meeting the remedial action objectives for groundwater and surface water are presented in Table 6-2. The active remediation methods proposed for groundwater simultaneously address soil contamination cleanup. Only limited action technologies are proposed for surface water contamination because of the limited extent and low concentrations.

6.2.4 General Response Actions for Air

Potential general response actions for the air pathway at Kotzebue LRRS include no action, limited action, and containment. Because limited evidence of harmful airborne contaminants exists for the site, response actions for this media are limited to air monitoring for volatile organics and controlling fugitive emissions of dust during any remediation construction activities. Dust and vapor containment is considered for soils and sediment.

6.3 IDENTIFICATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS

This section identifies a broad range of remedial action technologies and process options applicable to potential environmental problems associated with Kotzebue LRRS. In accordance with EPA guidance (EPA 1988), the initial identification and screening of technologies and process options has been performed separately for each of the potentially contaminated media under consideration at Kotzebue LRRS. Air media have been eliminated from further consideration as not requiring response actions. The need to control dust and vapor generation during a remedial action will be considered, however.

Due to the remote location of Kotzebue, Alaska, the screening of technologies will incorporate the consideration of logistical, environmental, and climatic limitations. Extreme climate conditions eliminate many potential remedial actions and limit others to an approximate three to four month period each year. The average break-up and freeze-up dates for the Kotzebue area are 17 May to 8 June and 2 October to 5 November, respectively (Schroeder et al. 1987). Transportation to and from Kotzebue is limited to scheduled barge transport (two to three times a year) and air service. The native tundra environment is fragile, and remedial actions that do not cause damage to tundra and underlying permafrost will be favored. A detailed discussion regarding the environmental setting at Kotzebue LRRS is provided in Section 2.0.

Several sources of information were consulted to assure that a broad spectrum of potentially applicable technologies and process options are identified and screened (Rich and Cherry 1987; Martin and Johnson 1987). Additional guidance for the identification and screening of remediation technologies has been developed jointly by U.S. EPA and the U.S. Air Force (EPA and USAF 1993), and was consulted in the development of this section.

6.3.1 Initial Identification and Screening of Technologies and Process Options

The identification of potentially applicable technologies begins with the development of general response actions, provided in Table 6-2. Remedial technologies are then identified and subdivided into specific process options. In this manner, each of the general response actions is expanded into numerous specific technologies and process options that might be applicable in conducting a general response action. Table 6-3 provides a description of the technologies available for the remediation of soil, groundwater, and surface water at Kotzebue LRRS.

TABLE 6-3. DEFINITION OF POTENTIAL REMEDIAL TECHNOLOGIES
(Page 1 of 3)

General Response Actions	Media	Remedial Technology	Description
NO ACTION	Soil/Groundwater/ Surface Water	Not applicable	Consideration of the No Action alternative is required by the NCP.
LIMITED ACTION	Soil/Groundwater/ Surface Water	Site controls	Use of contaminated areas is physically restricted. Typically, control and reduction of risk to human health and the environment are limited to fencing the contaminated sites to deter people and wildlife from entering and/or posting signs to warn local residents that contaminants at the site may pose a potential danger.
	Soil/Groundwater/ Surface Water	Institutional controls	Institutional controls are land use restrictions that address future use of contaminated sites. Deed restrictions and zoning limitations are examples of institutional controls.
	Soil/Groundwater/ Surface Water	Long-term monitoring	Soil and/or water samples are collected from impacted sites and analyzed for contaminants of concern on an established time schedule. Analytical results are used to evaluate contaminant degradation and mobility.
	Soil/Groundwater/ Surface Water	Natural attenuation	Natural processes such as dilution, volatilization, biodegradation, adsorption, and chemical reactions act to reduce contaminant concentrations to acceptable levels. Sampling and sample analysis throughout the process are required.
CONTAINMENT	Soil	Capping	Capping provides containment by minimizing vertical movement of contamination and reducing the likelihood of human and animal contact with contamination. Capping consists of covering the contaminated area with a low-permeability cover to prevent the infiltration of surface water, a drain layer of gravel above the cap to direct precipitation, and a vegetative covering that prevents erosion and restores the area's native vegetation. May be used to control aquifer recharge in contaminated areas.
	Soil	Surface controls	The surface and near-surface hydrology regime is modified by the installation of cutoff channels and trenches to reduce the downgradient migration of contaminants. Surface controls can be lined and used for collection of precipitation or contaminated media.
EXTRACTION	Soil	Excavation	Excavation using conventional earthmoving equipment is the common method of extracting contaminated soil at and below the ground surface. Excavation methods are typically not affected by waste types or technical requirements at sites.

TABLE 6-3. DEFINITION OF POTENTIAL REMEDIAL TECHNOLOGIES
(Page 2 of 3)

General Response Actions	Media	Remedial Technology	Description
EX SITU **TREATMENT**		PHYSICAL/CHEMICAL PROCESSES	
	Soil	Soil washing	Contaminants sorbed onto soil particles are separated from soil using an aqueous-based system. The wash water may be augmented with a basic leaching agent, surfactant, pH adjustment, or chelating agent to help remove organic or heavy metal contaminants.
		Solidification/stabilization	Contaminants are physically bound or enclosed within a stabilized mass (solidification), or chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility (stabilization). Cement and lime kiln dust are commonly used agents.
		Soil vapor extraction	A vacuum is applied to a network of piping run within a waste pile to encourage volatilization of organics from the excavated media. The process typically includes a system for the handling and treatment of off-gases.
		BIOLOGICAL PROCESS	
	Soil	Slurry phase biological treatment (bioreactor)	An aqueous slurry is created by combining contaminated soil with water and other additives. The slurry is typically mixed to keep solids suspended and microorganisms in contact with soil contaminants. Nutrients, oxygen, and pH in the bioreactor may be controlled to enhance biodegradation. Upon completion of the process, the slurry is dewatered and the treated soil is disposed or used as fill.
		Enhanced biodegradation	Excavated soils are mixed with soil amendments and placed in lined enclosures that typically have leachate collection systems and some form of aeration. Processes include prepared treatment beds, biotreatment cells, soil piles, and composting. Moisture, heat, nutrients, oxygen, and pH may be controlled to enhance biodegradation.
		Landfarming	Contaminated soils are spread on a liner and are periodically turned over (tilled) to aerate the contaminated soil and release volatile constituents through volatilization and photolysis.
		THERMAL PROCESSES	
	Soil	Low-temperature thermal desorption	Wastes are heated to 200°-600° F (93°-315° C) to volatilize water and organic contaminants. A carrier gas or vacuum system transports the volatilized water and organic contaminants to a gas treatment system.
		High-temperature thermal desorption	Wastes are heated to 600°-1,000° F (315°-538° C) to volatilize water and organic contaminants. A carrier gas or vacuum system transports the volatilized water and organic contaminants to an off-gas treatment system.

TABLE 6-3. DEFINITION OF POTENTIAL REMEDIAL TECHNOLOGIES
(Page 3 of 3)

General Response Actions	Media	Remedial Technology	Description
***IN SITU* TREATMENT**	PHYSICAL/CHEMICAL PROCESSES		
	Soil/Groundwater	Vapor extraction	A vacuum is applied to extraction wells using a manifold system to create a pressure gradient that induces gas-phase volatile contaminants to diffuse through soil to extraction wells. The process includes a system for handling and treating off-gases. This technology also is known as *in situ* soil venting, *in situ* volatilization, enhanced volatilization, or soil vacuum extraction.
		Soil flushing	Water, or water containing an additive to enhance contaminant solubility, is applied to soil or injected into groundwater to saturate the contaminated soil zone. Contaminants are leached into the groundwater, which is then extracted and treated.
	Soil	Solidification/stabilization	Contaminants are physically bound or enclosed within a stabilized mass (solidification), or chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility (stabilization). Cement and lime kiln dust are commonly used agents.
	Soil/Groundwater	Hot water or steam flushing/stripping	Steam is forced into an aquifer through injection wells to vaporize volatile and semivolatile contaminants, which rise to the unsaturated zone where they are removed by vacuum extraction and are then treated. Processes include contained recovery of oil waste, steam injection and vacuum extraction, *in situ* steam enhanced extraction, and steam enhanced recovery process.
	BIOLOGICAL PROCESSES		
	Soil/Groundwater	Enhanced Biodegradation	The activity of naturally occurring microbes is stimulated by circulating water-based solutions through contaminated soils to enhance *in situ* biological degradation of organic contaminants. Nutrients, oxygen, or other amendments may be used to enhance biodegradation and contaminant desorption from the subsurface.
		Bioventing	Oxygen is delivered to contaminated unsaturated soils by forced air movement (either extraction or injection of air or both) to increase oxygen concentrations and stimulate biodegradation. The system also may include the injection of contaminated gases, wherein the soil system is used for remediation.
OFF-SITE TREATMENT	Soil/Groundwater	Excavation and Off-Site Disposal	Contaminated material is removed and transported to permitted off-site treatment and disposal facilities. Pre-treatment may be required.
	Soil	Reclamation	Uses hydrocarbon-contaminated soil as a raw material in producing hot-mix asphalt (HMA) or as a road base. Contaminated soil is used to supplement aggregate in a 5/95 proportion. HMA is usually produced on a limited basis due to the seasonal nature of road construction.
	Soil	Treatment	The contaminated media is extracted from the site and transported to an off-site facility for treatment.

Table 6-4 provides the initial screening of technologies and process options. Each process option is accompanied by a brief description, followed by a screening comment regarding its applicability in meeting the general response action. Process options considered not applicable are shaded in the table. If all of the process options representing a particular technology are shaded, then the technology is also shaded, indicating that the technology will not be considered further. *Ex situ* treatment technologies have been screened with regard to both onsite and off-site treatment options. Off-site treatment and/or disposal options are restricted by the limited transportation options to and from Kotzebue; either by barge (two or three times) during summer months or by limited air transport service. These forms of transportation are likely prohibitively expensive in regards to *ex situ* treatment options. Off-site treatment and/or disposal is not considered applicable because onsite treatment technologies can effectively achieve TPH remediation without the logistical concerns associated with off-site treatment and disposal.

Thermal treatment process options have been identified during the initial screening of remedial technologies that can be applied to the removal of TPH in soil (e.g., rotary kiln, fluidized bed, etc.). However, a number of thermal treatment options have been considered to be inapplicable based on excessive energy requirements, technical implementation constraints due to logistics and climate conditions, and other identified onsite treatment options that can achieve TPH remediation without similar constraints.

6.3.1.1 Soil/Sediment. This section identifies technologies and selected process options to be developed into remedial alternatives for contaminated soils at Kotzebue LRRS. Based on the information presented in Table 6-4, process option(s) are selected from each technology for consideration in the assembly of remedial alternatives. The development of remedial action alternatives for soil is discussed in Section 6.4, while the following section discusses the process option(s) chosen to represent each of the technologies shown in Table 6-4.

Limited Action Technology - Access Restrictions (Institutional/Site Controls)--Deed restrictions and signage are combined to represent this technology. Fencing already exists within limited areas around the active radar dome at Kotzebue LRRS. However, the cost of fencing 15 additional areas and the maintenance required eliminates this process option from further consideration. Access restriction may be implemented by the placement of warning signs. It is anticipated that minimally attended radar operations will be maintained at current (or possibly reduced) levels over the next few years at Kotzebue

TABLE 6-4. INITIAL SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS FOR KOTZEBUE LRRS
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General Response Actions	Remedial Technology	Process Options	Description	Screening Comments
No Action	None	Not Applicable	No Action.	Potentially applicable; required for consideration by NCP.
Limited Action	Institutional controls	Deed and Planning/Zoning Restrictions	Property deed restrictions to control future use of the property; planning/zoning to avoid conflicting land use.	Potentially applicable.
	Site Controls	Fencing/Signage	Fencing at the site to physically restrict uncontrolled access. Posting signs to warn of contamination.	Fencing 15 contaminated source areas is not practical particularly considering the severe climate and maintenance involved.
	Natural Attenuation	Natural Attenuation of Groundwater	Reduction of contaminant concentrations in groundwater through the action of natural subsurface processes.	Potentially applicable; natural biodegradation assessment and monitoring would be required.
		Natural Attenuation of Surface Water	Reduction of contaminant concentrations in surface water through the action of natural processes.	Potentially applicable; natural biodegradation assessment and monitoring would be required.
		Natural Attenuation of Soils	Reduction of contaminant concentrations in soils through the action of natural surface and subsurface processes.	Potentially applicable; natural biodegradation assessment and monitoring would be required.
	Monitoring	Groundwater Monitoring	Monitoring of groundwater for the early detection of downgradient contaminant migration.	Potentially applicable; considered an adjunct to other technologies (e.g., natural attenuation).
		Surface Water Monitoring	Monitoring for contaminant migration in surface waters.	Potentially applicable; considered an adjunct to other technologies (e.g., natural attenuation).
		Air Monitoring	Monitoring around the site for airborne contaminants.	Potentially applicable; considered an adjunct to other technologies (e.g., during remedial actions).
		Surface and Near-Surface Soil Monitoring	Periodic monitoring of surface soils to evaluate contaminant degradation and/or mobility.	Potentially applicable; considered an adjunct to other technologies (e.g., natural attenuation).
Containment	Capping	Native Soil Cap	Cover with local soil to ensure all of the site has a minimum depth of clean cover.	Not effective because soil would sorb underlying soil with TPH and increase volume of source.
		Asphalt Cap	Spray or rolled application of a layer of asphalt over a contaminated area.	Not effective because of potential frost heaving, may adversely impact permafrost layer. Typically requires runoff control.

TABLE 6-4. INITIAL SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS FOR KOTZEBUE LRRS
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General Response Actions	Remedial Technology	Process Options	Description	Screening Comments
Containment (Cont.)	Capping (Cont.)	Concrete Cap	Installation of a concrete slab over the contaminated area(s).	Not effective because of potential frost heaving, may adversely impact permafrost layer. Typically requires runoff control.
		Clay Cap	Installation of a compacted clay (or clay/soil mixture) over contaminated area(s), likely with a soil cover for revegetation.	Not effective because of potential frost heaving, may adversely impact permafrost layer. Typically requires runoff control. Scattered sites (16) would make it difficult and costly to install.
		Synthetic Membrane Cap	Installation of a synthetic membrane with a soil cover.	Not effective because of severe climatic conditions. May adversely impact permafrost layer. Typically requires runoff controls. Scattered sites (16) would make it difficult and costly to install.
		Multi-layer Cap	Clay and synthetic membrane layers with a soil cover.	Not effective because of severe climatic conditions. May adversely impact permafrost layer. Typically requires runoff controls. Scattered sites (16) would make it difficult and costly to install.
	Surface Controls	Interception Trenches	Installation of cutoff trenches to modify surface and near-surface hydrology regime to reduce downgradient migration of contaminants.	Not practical because of scattered location of source areas and treatment system requirements for collected waters.
		Surface Water Management	Surface water collection to prevent infiltration into contaminated zones.	Not practical because of treatment system requirements.
	Dust Controls	Revegetation	Establishment of site-specific vegetation to control wind erosion.	Potentially applicable.
		Wind Fences	Installation of a porous screen to deflect wind and decrease wind velocity across the soil surface.	Potentially applicable; considered an adjunct to other technologies (e.g., during remedial actions).
		Water Sprays	Frequent application of water to surface soils, primarily in well-traveled areas to reduce fugitive dust emissions.	Potentially applicable; considered an adjunct to other technologies (e.g., during remedial actions).
Extraction	Removal Technologies (Excavation)	Soil Excavation	Excavation of soil through normal construction means (e.g., backhoes, front-end loaders, etc.)	Potentially applicable; considered an adjunct to other technologies that require removal of contaminated soils.

TABLE 6-4. INITIAL SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS FOR KOTZEBUE LRRS
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General Response Actions	Remedial Technology	Process Options	Description	Screening Comments
Ex Situ Treatment	Physical/Chemical Extraction	Hot Air Vapor Extraction	Hot air circulated through a network of piping in a soil cell. Extraction piping moves contaminated vapor to burn chamber for decontamination and then recirculation.	Potentially applicable. Requires propane or diesel fuel source. Climatic conditions will limit duration of treatment.
		Soil Washing	Use of water or steam to wash/spray contaminants from soil.	Potentially applicable; may require surfactant use to be effective. Effluent would likely require treatment.
	Solidification/Stabilization	Macroencapsulation	Encapsulates entire material with an impermeable coating.	Not applicable; not proven effective for organic contamination.
		Microencapsulation	Material is dried, then mixed with a bonding agent.	Not applicable; not proven effective for organic contamination.
	Biological	Slurry Phase Biological Treatment (Bioreactor)	An aqueous slurry is created by combining contaminated soil with water and other additives.	Not applicable; typically used for treatment of wastewaters. Effluent produced may require further treatment. Bioreactor would be difficult to implement and maintain during extended cold periods.
		Landfarming/Enhanced Biodegradation	Excavated soils are mixed with soil amendments to promote oxidation, photochemical reaction, biodegradation, etc. Landfarm soils are placed in lined enclosures that typically have leachate collection systems and some form of aeration.	Potentially applicable; the amount and concentrations of TPH contaminated soils could require multiple treatment areas. Climatic conditions will limit duration of treatment and rate of TPH degradation.
		Cultured Microorganisms (Innoculation)	Cultured microorganisms specifically designed to degrade a specific waste.	Potentially applicable; use of cultured microorganisms could be incorporated with landfarming technology.

TABLE 6-4. INITIAL SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS FOR KOTZEBUE LRRS
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General Response Actions	Remedial Technology	Process Options	Description	Screening Comments
Ex Situ Treatment (Cont.)	Thermal	Wet Air Oxidation	Oxidizes dissolved or finely divided organics using moderate temperatures and high pressure.	Not applicable. This technology is generally selected for treating wastes that are not readily amenable to biological treatment. May require pretreatment for waste to achieve physical requirements. On- or off-site implementation of technology is logistically and climatically limited.
		Rotary Kiln	Combustion in a horizontally rotating cylinder designed for uniform heat transfer.	Not applicable; excessive temperature (energy) requirements for onsite treatment and implementation based on logistical and climate conditions. Air emissions may also require treatment.
		Thermal Desorption	Use of elevated temperatures to volatilize contaminants, facilitating their removal from soil.	Potentially applicable; may be effective at reducing TPH concentrations (alternative to onsite incineration). Air emissions may require treatment.
		Fluidized Bed	Waste injected into hot agitated bed of sand where combustion occurs.	Not applicable, due to excessive temperature (energy) requirements for onsite treatment and implementation based on logistical and climate conditions. Air emissions may also require treatment.
		Vitrification	Material is heated in a furnace/incinerator to its melting temperature which forms a glassy mass.	Not applicable; excessive energy requirements, logistical implementation restrictions, and output that is difficult to handle.
		Pyrolysis-Incineration	Chemical decomposition of waste by heating the material in the absence of oxygen.	Not applicable; excessive temperature (energy) requirements for onsite treatment and implementation based on logistical and climate conditions.
In Situ Treatment	Physical/Chemical	Oxidation	Use of a chemical oxidant to oxidize contaminants to, less toxic compounds such as carbon dioxide, water, salts, simple organic acids, sulfates, etc.	Not applicable. Although capable of destroying organic contaminants, may also produce more soluble and toxic byproducts than are parent compounds. Chemical oxidation is used primarily for treatment of dilute wastestreams containing oxidizable organics.
		Soil Flushing	Extraction of organic or inorganic compounds from soil by injection/recirculation of solvent through the soil.	Not applicable due to frozen ground most of year.

TABLE 6-4. INITIAL SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS FOR KOTZEBUE LRRS
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General Response Actions	Remedial Technology	Process Options	Description	Screening Comments
In Situ Treatment (Cont.)	Physical/Chemical (Cont.)	Solidification	Grout is injected directly into the soil.	Not applicable; grout does not effectively bind TPH contamination.
		Vacuum Vapor Extraction	Vacuum is applied to extraction wells using a manifold system to induce volatile diffusion through soil to extraction wells.	Not applicable due to frozen ground most of year, thin vadose zone, high (variable) soil moisture content.
	Biological	Enhanced Biodegradation	Soils are amended with emulsification agents and nutrients to enhance natural biodegradation by native microorganisms.	Potentially applicable; requires natural attenuation evaluation, bench scale testing.
		Cultured Microorganisms (Innoculation)	Uses microorganisms to degrade hazardous organics.	Potentially applicable; requires natural attenuation evaluation, bench scale testing.
		Bioventing	Oxygen is delivered to contaminated unsaturated soils by forced air movement.	Not applicable due to frozen ground most of year, thin vadose zone, high (variable) soil moisture content.
Offsite Treatment	Landfill	Off-Site (Without Treatment)	Excavation of contaminated soil, then transporting it to, and redepositing it in, an approved storage facility.	Not applicable. Identified onsite technologies can effectively achieve TPH remediation without logistical requirements and high cost associated with offsite disposal.
	Incineration/Landfill	Off-Site (After Treatment)	Excavate soil, then transport, treat, and redeposit residuals in an approved storage facility.	Not applicable; identified onsite technologies can effectively achieve TPH remediation without logistical requirements and high cost associated with offsite disposal.
	Reclamation	On-Site Redeposition (After Treatment)	Excavate and treat contaminated soils, then redeposit onsite.	Potentially applicable; treated soils would require confirmation sampling to assure compliance with remedial action objectives prior to redeposition onsite.
	Beneficial Use	Onsite or Off-Site	Use of hydrocarbon-contaminated soil as raw material in producing hot-mixed asphalt or as road base.	Not applicable. Construction with asphalt at Kotzebue is limited and does not provide significant opportunity to use this technology.

LRRS. Institutional controls, such as deed restrictions and zoning restrictions, could be applicable to Kotzebue LRRS if the USAF transfers land ownership to another party in the future.

Limited Action Technology - Natural Attenuation/Monitoring--Natural attenuation and long-term monitoring are combined to represent this technology, in which natural surface and subsurface processes function to reduce contaminant concentrations to acceptable levels over time. Long-term monitoring is required throughout the process to evaluate the progress and remedial effectiveness of this technology. Long-term monitoring may incorporate periodic surface and near-surface soil sampling, surface water sampling, and/or groundwater sampling and analysis to evaluate natural attenuation processes. This technology has been considered potentially applicable for sites at Kotzebue LRRS based on the following rationale:

- Logistical, climatic, and environmental constraints severely limit remedial action alternatives at Kotzebue LRRS

- Significant impacts on potential receptors are limited due to the nature of contamination (primarily middle-distillate fuels) and the remote location of the site.

- Remedial actions that do not cause damage to the tundra and underlying permafrost are favored.

Additional options exist that may be used to enhance the *in situ* degradation of TPH contamination; these options are described later in this section.

Containment Technology - Dust Control--Water spray is the easiest means to accomplish control of potential dust and vapor emissions that may be encountered during implementation of remedial action alternatives. Because long-term forms of airborne contamination generation are not a problem at Kotzebue LRRS, this is the option of choice.

Extraction Technology - Excavation--Excavation is a common method of extracting contaminated soils using earthmoving equipment. Excavation of soils will be required for all *ex situ* treatment technologies and for on- or off-site disposal options. Excavation technology is not limited by the contam-

inant source or by technical requirements at Kotzebue LRRS. However, extreme climate conditions limit the use of this technology to approximately three months during the summer. Excavation activities could adversely impact undisturbed native tundra vegetation, and could affect the shallow permafrost horizon.

***Ex Situ* Treatment Technology - Physical/Chemical**--Soil washing and hot air vapor extraction are two process options identified as potentially applicable for this technology. Soil washing separates contaminants sorbed onto soil particles using an aqueous-based system which may incorporate a steam process. The wash water may be augmented with a surfactant to help remove organic contaminants. The hot air vapor extraction method places the excavated soil into a treatment cell, where it is treated with circulating hot air. The effectiveness of these technologies depends on factors including soil characteristics and contaminant type(s). They are most effective on coarse grained soil and work well on DRO. The soil washing technology could be combined with other process options (e.g., thermal desorption) to expedite DRO removal from soil.

***Ex Situ* Treatment Technology - Biological**--This technology is represented by the landfarming/ enhanced biodegradation process option, and could involve the use of cultured microorganisms to degrade organic contamination in soil. Excavated soils would potentially be treated onsite in a lined enclosure engineered with leachate collection and aeration systems. The technology includes the mixing of contaminated soils with amendments to promote biodegradation. Extreme climate conditions limit the duration of treatment to approximately three months annually. Bench-scale testing is generally required to determine optimum process requirements prior to onsite implementation.

***Ex Situ* Treatment Technology - Thermal**--Thermal desorption is the process option of choice for this technology. Other thermal processes such as rotary kiln (incineration) and vitrification have been considered to be inapplicable based on excessive energy requirements for onsite treatment, and on technical implementation constraints resulting from logistical and climatic conditions. Thermal desorption is a technology that has been used extensively in the treatment of petroleum contaminated soils. Mobile thermal desorption units have been used to remediate TPH contaminated soils in arctic environments similar to that in Kotzebue, with reported high efficiency and process rates. The treatment efficiency and soil process rates are dependent on soils type and initial TPH concentration.

In Situ Treatment Technology - Biological--Enhanced bioremediation, with possible use of cultured microorganisms, represents this technology. Enhanced bioremediation includes the amendment of site soils with emulsification agents and nutrients to enhance natural biodegradation by native microorganisms. The potential *in situ* application of cultured microorganisms could also be considered. Extreme climate conditions limit the duration of this treatment to approximately three months annually. Bench-scale testing is generally required to evaluated potential treatment efficiencies and determine optimum process requirements prior to onsite implementation.

Disposal Technology - Reclamation--Onsite redeposition of soils after *ex situ* treatment represents this disposal technology. Treated soils would require confirmation sampling and regulatory approval to assure compliance with established remedial action objectives prior to onsite redeposition.

6.3.1.2 Groundwater and Surface Water. Based on the information presented in Table 6-4, process option(s) are selected from each technology for consideration in the assembly of remedial alternatives for contaminated groundwater and surface water. Limited action alternatives for groundwater and surface water remediation are the only response actions to progress beyond the initial screening process. Source control pertaining to soil remediation will be the contributing factor for maintaining and/or improving surface water and groundwater quality.

6.4 DEVELOPMENT OF ALTERNATIVES

The viable remedial technologies and selected process options discussed in Section 6.3 that are considered separately or in combination in the development of remedial action alternatives are presented in Table 6-5 for groundwater, surface water, and soils. The alternatives for soils have been assembled to specifically address the varied lithologic types present at Kotzebue LRRS. The order in which alternatives are presented is coincidental, and does not represent a prioritization or weighting.

The supporting or adjunct technologies that may be used in conjunction with many of the remedial action alternatives, such as long-term monitoring, dust control, and excavation of soils are identical for the purposes of assembling remedial action alternatives. Rather than repeating a description of these adjunct

TABLE 6-5. REMEDIAL ACTION ALTERNATIVES ASSEMBLED FOR SOILS, SURFACE WATER, AND GROUNDWATER AT KOTZEBUE LRRS
Soils/Sediment
Fill Materials
Alternative 1. No Action Alternative 2. Access Restriction, Natural Attenuation/Monitoring Alternative 3. *In Situ* Enhanced Biodegradation Alternative 4. Excavation, Onsite Treatment by Thermal Washing Alternative 5. Excavation, Onsite Enhanced Biodegradation
Native Soils
Alternative 1. No Action Alternative 2. Access Restriction, Natural Attenuation/Monitoring Alternative 3. *In Situ* Enhanced Biodegradation
Beach Sands and Gravels
Alternative 1. No Action Alternative 2. Access Restriction, Natural Attenuation/Monitoring Alternative 3. *In Situ* Enhanced Biodegradation Alternative 4. Excavation, Onsite Treatment by Thermal Washing Alternative 5. Excavation, Onsite Enhanced Biodegradation
Near-Beach Groundwater/Surface Water
Alternative 1. No Action Alternative 2. Access Restriction, Natural Attenuation/Monitoring

technologies each time they are involved in an alternative, they are described where first used, and are referenced to that description where used thereafter.

6.4.1 Development of Alternatives for Soil/Sediment

Remedial action objectives for soil and sediment include consideration of the three primary lithologic types that characterize Kotzebue LRRS: beach sands and gravels, native soils associated with the tundra hill and surrounding area, and fill material used for roads and facility foundations (see Section 6.1.1.1). A detailed description of the environmental setting at Kotzebue LRRS is provided in Section 2.0. This section presents remedial action alternatives assembled as appropriate to address contamination associated with the lithologies present at Kotzebue LRRS. Limited remedial options are presented for potentially contaminated native tundra; active or invasive forms of remediation have been precluded for native tundra due to its sensitive nature and to satisfy ADEC instructions to avoid damage to native tundra.

6.4.1.1 Fill Material. Petroleum hydrocarbon contamination linked to past installation operations and activities is the primary environmental problem identified at Kotzebue LRRS. Engineered fill materials used for roads and facility foundations are associated with most sites and areas of concern at Kotzebue LRRS. The following remedial action alternatives have been assembled to address contamination in engineered fill materials. Remediation goals include the consideration of remedial actions that focus on the isolation and/or removal of potential source areas in fill materials.

Alternative 1. No Action

Under the no action alternative, the site would be left in its current state, with no activities to control or mitigate exposure to site contaminants. The no action alternative provides a baseline for comparing other remedial alternatives, and is required for consideration by the NCP.

Alternative 2. Access Restriction, Natural Attenuation/Monitoring

Under this alternative, the USAF maintains long-term ownership of the site and takes responsibility for restricting access to contamination areas. Placement of warning signs is an implementable means of limiting human access and avoiding costly construction and maintenance fees for fencing.

Natural attenuation does not involve active remedial measures. In this alternative, natural surface and subsurface processes function to reduce contaminant concentrations to acceptable levels over time. Natural attenuation of petroleum hydrocarbons in soils has been demonstrated at Kotzebue LRRS (Section 4.6.6, Natural Attenuation Assessment Results). However, the rate of petroleum hydrocarbon degradation has not been established, and extended cold periods likely slow natural attenuation processes. Long-term monitoring is required to evaluate the reduction of contaminant concentrations over time and to monitor for potential offsite contaminant migration.

Alternative 3. *In Situ* Enhanced Biodegradation

This alternative involves the surface application of soil amendments such as emulsification agents and nutrients to enhance natural biodegradation by native microorganisms. This alternative could incorporate the use of cultured microorganisms to further promote biodegradation in soils. Extreme climate conditions limit the duration of treatment to approximately three months each year. Bench-scale testing is generally required to evaluate potential treatment efficiencies and to determine optimum process requirements prior to onsite implementation.

Alternative 4. Excavation, Onsite Treatment by Thermal Washing

This alternative, thermal washing treatment, involves a combination of soil washing and low temperature thermal desorption. Hot air vapor extraction and thermal desorption would also be effective treatment methods for soil remediation at Kotzebue LRRS. However, thermal washing has been chosen to represent physical/chemical extraction and thermal methods of remediation, because its energy requirements are cost effective for remote site operation, and it has proven to be an effective treatment method when used on Alaska's North Slope.

A mobile thermal washing treatment unit could be transported to the site by barge or aircraft. Excavated soils would be washed using high-pressure superheated steam to volatilize light-fraction and middle distillate petroleum hydrocarbons. Wash water is collected, filtered to remove remaining heavier hydrocarbons and/or particulates, and recycled, thus reducing or eliminating disposal requirements. Hydrocarbons volatilized by the superheated steam are evacuated by a vacuum system, condensed back into liquid form, and are bioremediated in a wastewater tank that is part of the system, eliminating the

need for air permitting and the offsite disposal of wastes. Treatment efficiency and soil processing rates are dependent on soil type and initial TPH concentrations.

Alternative 5. Excavation, Onsite Enhanced Biodegradation

Under this alternative, contaminated soils would be excavated and placed in an onsite lined enclosure (treatment cell) with an engineered leachate collection system and a means of aerating the contained soils. The treatment cell could also be placed inside of a temporary structure or building onsite. Treatment would consist of mixing the contaminated soils with amendments (i.e., nutrients, emulsifiers, oxygen, cultured microorganisms, etc.) to promote oxidation and biodegradation. This alternative would require periodic sampling throughout the process to evaluate the effectiveness of treatment. Bench-scale testing is generally required to determine optimum requirements prior to onsite implementation. The construction of an indoor treatment cell would eliminate some of the problems that diminished the effectiveness of the previously constructed landfarm cells. Climatic conditions and lack of available maintenance alternatives resulted in the addition of the landfarm areas as another area of concern investigated during this RI field effort.

6.4.1.2 Native Soils. An integral aspect of each remedial action objective is to minimize potential negative impacts of the remedial response being considered. Because of the fragile nature of the native tundra environment at Kotzebue LRRS, the following remedial alternatives have been assembled to minimize the potential for damage to native tundra and the underlying permafrost.

Alternative 1. No Action

This alternative is described in Section 6.4.1.1, Fill Material; Alternative 1.

Alternative 2. Access Restrictions, Natural Attenuation/Monitoring

This alternative is described in Section 6.4.1.1, Fill Material; Alternative 2. Most sites under investigation at Kotzebue LRRS are situated atop the tundra hill, located approximately 0.25 miles east of Kotzebue Sound. From the tundra hill, native tundra slopes moderately to steeply to the west (toward Kotzebue Sound) and moderately to the east (toward wetland areas). Fencing in areas of native tundra

will be difficult to install and maintain due to the presence of extremely shallow permafrost and the general topography of the tundra hill. Therefore fencing will not be recommended in these areas and access restriction will be implemented by posting signs.

Alternative 3. *In Situ* Enhanced Biodegradation

This alternative is described in Section 6.4.1.1, Fill Material; Alternative 3.

6.4.1.3 Beach Sands and Gravels. The following remedial alternatives have been assembled to address potential contamination associated with beach sands and gravels at Kotzebue LRRS.

Alternative 1. No Action

This alternative is described in Section 6.4.1.1, Fill Material; Alternative 1.

Alternative 2. Access Restrictions, Natural Attenuation/Monitoring

This alternative is described in Section 6.4.1.1, Fill Material; Alternative 2. Tidal flushing of beach sands and gravels and periodic storm wave action likely accelerate natural attenuation processes in this media.

Alternative 3. *In Situ* Enhanced Biodegradation

This alternative is described in Section 6.4.1.1, Fill Material; Alternative 3.

Alternative 4. Excavation, Onsite Treatment by Thermal Washing

This alternative is described in Section 6.4.1.1, Fill Material; Alternative 4.

Alternative 5. Excavation, Onsite Enhanced Biodegradation

This alternative is described in Section 6.4.1.1, Fill Material; Alternative 5.

6.4.2 Near-Beach Groundwater/Surface Water

Only the no action and limited action alternatives will be considered to address contaminated groundwater and surface water. Source remediation of contaminated soils should rapidly improve the quality of both surface water and groundwater for the site. The discussions of the no action and access restriction alternatives provided in Sections 6.4.1.1 and 6.4.1.2 also apply to this section. Groundwater and surface water monitoring will be recommended as needed.

6.5 DETAILED ANALYSIS OF ALTERNATIVES

A detailed analysis of alternatives is based on nine evaluation criteria developed by the EPA to support the CERCLA process. The nine evaluation criteria are discussed in the EPA guidance document (U.S. EPA 1988) and listed below.

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume
- Short-term effectiveness
- Implementability
- Cost
- ADEC (and EPA) acceptance
- Community acceptance

The first two criteria are considered threshold levels which must be satisfied for an alternative to be accepted. However, there is a waiver process for ARARs under EPA directed cleanups. Because this action is being directed under the USAF IRP, justification for ARAR compliance with selected remedial action alternatives is provided in Table 6-6. The next five criteria, beginning with long-term effectiveness and permanence provide the basis for the analysis. The final two criteria involve both regulatory and community acceptance which will be satisfied during the review process.

TABLE 6-6. ARAR EVALUATION FOR REMEDIAL ACTION ALTERNATIVES AT KOTZEBUE LRRS
(Page 1 of 2)

Federal ARAR	Alternative 1: No Action	Alternative 2: Access Restriction, Natural Attenuation/Monitoring	Alternative 3: *In Situ* Enhanced Biodegradation	Alternative 4: Excavation, Onsite Treatment by Thermal Washing	Alternative 5: Excavation, Onsite Enhanced Biodegradation
Clean Water Act	Ambient water quality standards exceeded.	Ambient water quality standards exceeded.	Ambient water quality standards exceeded.	Source remediation should improve ambient water quality standards.	Source remediation should improve ambient water quality standards.
	Effluent discharge will not occur with implementation of this alternative.	Effluent discharge will not occur with implementation of this alternative.	Effluent discharge will not occur with implementation of this alternative.	Effluent discharge will not occur with implementation of this alternative.	Effluent discharge will not occur with implementation of this alternative.
	Soil contamination could migrate to other wetlands areas without source remediation.	Soil contamination could migrate to other wetlands areas without source remediation.	Remediation activities should not compromise wetland areas.	Excavation activities should be performed in a manner that protects wetlands.	Excavation activities should be performed in a manner that protects wetlands.
Clean Air Act	Remediation activity will not effect ambient air quality.	Remediation activity will not effect ambient air quality.	Remediation activity will not effect ambient air quality.	Dust control may be required to protect workers during excavation activities.	Dust control may be required to protect workers during excavation activities.
OSHA	NA	Site workers will comply with OSHA standards.	Site workers will comply with OSHA standards.	Site workers will comply with OSHA standards.	Site workers will comply with OSHA standards.
Endangered Species Act	NA	NA	NA	Excavation activities should be performed in a manner that protects wetlands.	Excavation activities should be performed in a manner that protects wetlands.
Coastal Zone Management Act	NA	NA	Remediation along Kotzebue Sound must consider CZMA statute.	Remediation along Kotzebue Sound must consider CZMA statute.	Remediation along Kotzebue Sound must consider CZMA statute.
Executive Order #11990 on Protection of Wetlands	No action could have adverse effect on wetlands, if source area is not remediated.	Limited action could have adverse effect on wetlands, if source area is not remediated.	Source migration could adversely effect wetlands.	Excavation activities should be designed to avoid adverse impacts to wetlands.	Excavation activities should be designed to avoid adverse impacts to wetlands.
Executive Order #11988 on Protection of Floodplains	NA	NA	NA	Excavation along beach sands and gravels must consider adverse effects to floodplain.	Excavation along beach sands and gravels must consider adverse effects to floodplain.
Migratory Bird Treaty Act of 1972	NA	Monitoring activities will consider this act.	Remediation activities will take this act into consideration.	Remediation activities will take this act into consideration.	Remediation activities will take this act into consideration.
Marine Mammal Protection Act	NA	Monitoring activities will consider this act.	Remediation activities will take this act into consideration.	Remediation activities will take this act into consideration.	Remediation activities will take this act into consideration.
Fish and Wildlife Conservation Act of 1980	NA	Sampling activities must consider impacts on wetlands, fisheries, and protected habitats.	Remediation activities must consider impacts on wetlands, fisheries, and protected habitats.	Excavation activities must consider impacts on wetlands, fisheries, and protected habitats.	Excavation activities must consider impacts on wetlands, fisheries, and protected habitats.
National historical Preservation Act	NA	NA	NA	Excavation activities will be halted if Native American artifacts are uncovered.	Excavation activities will be halted if Native American artifacts are uncovered.

TABLE 6-6. ARAR EVALUATION FOR REMEDIAL ACTION ALTERNATIVES AT KOTZEBUE LRRS
(Page 2 of 2)

State ARAR	Alternative 1: No Action	Alternative 2: Access Restriction, Natural Attenuation/Monitoring	Alternative 3: *In Situ* Enhanced Biodegradation	Alternative 4: Excavation, Onsite Treatment by Thermal Washing	Alternative 5: Excavation, Onsite Enhanced Biodegradation
Air Quality Control (AQC) Chapter 50	Remediation activity will not effect ambient air quality.	Remediation activity will not effect ambient air quality.	Remediation activity will not effect ambient air quality.	Dust control may be required to protect workers during excavation activities.	Dust control may be required to protect workers during excavation activities.
Solid Waste Management (SWM) Chapter 60	NA	NA	NA	Evaluate criteria for transportation of solid waste.	Evaluate criteria for transportation, landspreading, and long-term storage of solid waste.
Water Quality Standards (WQS) Chapter 70	Ambient water quality standards exceeded.	Ambient water quality standards exceeded.	Ambient water quality standards exceeded.	Source remediation should improve ambient water quality standards.	Source remediation should improve ambient water quality standards.
Oil and Hazardous Substances Pollution Control (OHPC) Chapter 75	May provide alternative for developing cleanup standards.	May provide alternative for developing cleanup standards.	May provide alternative for developing cleanup standards.	May provide alternative for developing cleanup standards.	May provide alternative for developing cleanup standards.

6.5.1 Analysis of Alternatives

Five remedial action alternatives have been developed to address environmental concerns at Kotzebue LRRS (see Table 6-5). A detailed analysis of the five alternatives as they pertain to gravel fill materials, native soils (tundra), beach sands and gravels, near-beach groundwater, and surface water at Kotzebue LRRS is provided in Table 6-7 and summarized below. The bases for the cost estimates are provided in Table 6-8.

6.5.1.1 Alternative 1: No Action. This alternative has been considered for fill material, native soil, beach sands and gravels, and surface water/groundwater. In general this alternative does not provide overall protection of human health and the environment, and it does not comply with ARARs. However, the results of the baseline risk assessment indicated that the beach sands and gravels area does not pose a significant risk (<1.0 E-6, HQ<1) to human health, and a limited environmental risk from exposure to xylenes. Based upon this information, no action in this area has some merit, and should be considered further.

There are also ARAR violations relative to the native soils, surface water, and groundwater, however, the baseline risk calculations for these areas are acceptable to both human health and the environment. As stated above, no action in these areas should be considered further.

The fill material does not comply with ARARs, and it has unacceptable risks to both human health, and the environment. No action for these areas does not warrant further consideration.

6.5.1.2 Alternative 2, Access Restriction, Natural Attenuation/Monitoring. The discussion presented for Alternative 1, also applies to this alternative. In addition monitoring would permit evaluation of natural attenuation processes, which will reduce toxicity, mobility, and volume of contaminants. However, it is likely that this process would prove to be too slow for the fill material, and limited cleanup of elevated soil contamination areas would be necessary.

6.5.1.3 Alternative 3, In Situ Enhanced Biodegradation. This alternative has been considered for fill material, beach sands and gravels, and native soils. Without the benefit of a treatability study, it is difficult to evaluate the time period necessary for this alternative to work. Because of the unknown time factor and in situ treatment, overall protection of human health and the environment, and compliance with

TABLE 6-7. DETAILED ANALYSIS OF ALTERNATIVES FOR KOTZEBUE LRRS
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Evaluation Criteria	Alternative 1: No Action Pertaining to: Fill Material, Native Soil, Beach Sands and Gravels, Groundwater/Surface Water	Alternative 2: Access Restriction, Natural Attenuation/Monitoring Pertaining to: Fill Material, Native Soil, Beach Sands and Gravels, Groundwater/Surface Water	Alternative 3: *In Situ* Enhanced Biodegradation Pertaining to: Fill Material, Native Soil, Beach Sands and Gravels	Alternative 4: Excavation, Onsite Treatment by Thermal Washing Pertaining to: Fill Material, Beach Sands and Gravels	Alternative 5: Excavation, Onsite Enhanced Biodegradation Pertaining to: Fill Material, Beach Sands and Gravels
Overall Protection of Human Health and the Environment	Limited risk to human health and the environment.	Limited risk to human health and the environment.	Limited protection of human health and the environment initially, but protection will increase with time.	Protective of human health and the environment.	Protective of human health and the environment.
Compliance with ARARs	Does not comply with ARARs.	Does not comply with ARARs.	Does not comply with ARARs initially, but will in time.	Does comply with ARARs.	Does comply with ARARs.
Long-Term Effectiveness					
Magnitude of Residual Risk	Original risk will diminish with natural attenuation.	Magnitude of original risk will diminish with natural attenuation. Access restriction will limit human exposure but not animal exposure.	Residual risk will diminish with time, but a five-year review will be required.	There will be no residual risk, and a five year review will not be necessary.	There will be no residual risk, and a five-year review will not be necessary.
Adequacy and Reliability of Controls	No significant control of sites access at this time.	Posting some areas will limit human access and exposure, but not change exposure to environmental receptors. Erosion could increase exposure, but it would also contribute to natural attenuation.	Annual sampling and nutrient application will determine rate of cleanup.	Confirmation sampling will determine limits of excavation and also verify that treated soil is clean. Long-term monitoring will not be required.	Confirmation sampling will determine limits of excavation, and also verify that treated soil is clean. Long-term monitoring will not be required.
Reduction of Toxicity, Mobility, and Volume					
Treatment process the remedy will employ and the materials they will treat	No treatment process employed.	No treatment process employed.	Soil amendments (nutrients, oxygen) will enhance biodegradation of TPH in soil.	Thermal washing will treat TPH in soil by utilizing a high pressure steam wash to volatilize hydrocarbons. The volatiles are evacuated by a vacuum system, condensed back into liquid form and bioremediated in a wastewater tank. Washwater is collected, filtered, and recycled.	Soil amendments (nutrients, oxygen) will enhance biodegradation of TPH in excavated soil placed in treatment cells.
Amount of hazardous materials that will be destroyed or treated, including how the principal threat(s) will be addressed	No hazardous material will be destroyed or treated.	No hazardous material will be destroyed or treated.	The contaminated source material will biodegrade with time until an action level is reached for TPH.	The contaminated source material will all be treated to a determined TPH cleanup level.	The contaminated source material will biodegrade with time until an action level is reached for TPH.

TABLE 6-7. DETAILED ANALYSIS OF ALTERNATIVES FOR KOTZEBUE LRRS
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Evaluation Criteria	Alternative 1: No Action Pertaining to: Fill Material, Native Soil, Beach Sands and Gravels, Groundwater/Surface Water	Alternative 2: Access Restriction, Natural Attenuation/Monitoring Pertaining to: Fill Material, Native Soil, Beach Sands and Gravels, Groundwater/Surface Water	Alternative 3: *In Situ* Enhanced Biodegradation Pertaining to: Fill Material, Native Soil, Beach Sands and Gravels	Alternative 4: Excavation, Onsite Treatment by Thermal Washing Pertaining to: Fill Material, Beach Sands and Gravels	Alternative 5: Excavation, Onsite Enhanced Biodegradation Pertaining to: Fill Material, Beach Sands and Gravels
Reduction of Toxicity, Mobility, and Volume (Cont.)					
The degree of expected reduction in toxicity, mobility, or volume measured as a percentage of reduction (or order of magnitude)	There will be some reduction in toxicity, mobility, and volume through natural attenuation processes.	There will be some reduction in toxicity, mobility, and volume through natural attenuation processes.	There will be a gradual reduction in toxicity, mobility, and volume as biodegradation progresses.	There should be total reduction of toxicity, mobility, and volume of contaminated soil.	There will be a gradual reduction in toxicity, mobility, and volume as biodegradation progresses.
The degree to which the treatment will be irreversible	NA	NA	As the process progresses it will be completely irreversible.	The treatment will be completely irreversible.	As the process progresses, it will be completely irreversible.
The type and quantity of treatment residuals that will remain following treatment	NA	NA	Because the treatment method is *in situ* there may be some areas of residual contamination after treatment has ceased. However, residuals should pose little if any risk.	The volume of excavated soil should remain unchanged. It will be sampled after treatment and placed back in the excavation or used elsewhere as clean fill.	Confirmation sampling will indicate when treatment is complete. Treated soil may be used as clean fill elsewhere or as backfill material onsite.
Whether the alternative would satisfy the statutory preference for treatment as a principal element	Preference for treatment not satisfied.	Preference for treatment not satisfied.	Preference for treatment is satisfied.	Preference for treatment is satisfied.	Preference for treatment is satisfied.
Short-Term Effectiveness					
Protection of community during remedial action	NA	NA	Because the remedial action is non-invasive, it poses no risk to the community.	The site is over a mile from Kotzebue and should not pose a risk to the community. Work areas will be flagged and posted as necessary to deter access by the general public.	The site is over a mile from Kotzebue and remediation activities should not pose a risk to the community. Work areas will be flagged and posted as necessary to deter access by the general public.
Protection of workers during remedial actions	NA	NA	Protective clothing will be worn as needed.	Dust control and protective clothing will be used for worker protection.	Dust control and protective clothing will be used for worker protection.
Environmental impacts	No change in risk.	Slight change in risk.	No expected environmental impact.	Excavation along beach could cause runoff to Sound.	Excavation along beach could cause runoff to Sound.

TABLE 6-7. DETAILED ANALYSIS OF ALTERNATIVES FOR KOTZEBUE LRRS
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Evaluation Criteria	Alternative 1: No Action Pertaining to: Fill Material, Native Soil, Beach Sands and Gravels, Groundwater/Surface Water	Alternative 2: Access Restriction, Natural Attenuation/Monitoring Pertaining to: Fill Material, Native Soil, Beach Sands and Gravels, Groundwater/Surface Water	Alternative 3: *In Situ* Enhanced Biodegradation Pertaining to: Fill Material, Native Soil, Beach Sands and Gravels	Alternative 4: Excavation, Onsite Treatment by Thermal Washing Pertaining to: Fill Material, Beach Sands and Gravels	Alternative 5: Excavation, Onsite Enhanced Biodegradation Pertaining to: Fill Material, Beach Sands and Gravels
Short-Term Effectiveness (Cont.)					
Time until remedial response objectives are achieved	Dependent upon rate of natural attenuation.	Dependent upon rate of natural attenuation. Posted areas will achieve remedial response objectives for human health upon installation of signs.	Dependent upon rate of biodegradation. Treatability study required along with annual monitoring and reapplication.	Two construction seasons would be required to process and cleanup 16,000 yd^3 of fill material. Six seasons would be required for 48,000 yd^3 of beach sands and gravels.	Dependent upon rate of biodegradation. Treatability study required along with annual monitoring and reapplication.
Implementability					
Technical Feasibility					
- Ability to construct and operate technology	NA	Signage material would have to be shipped into site.	Operation of technology does not involve construction, and application is straightforward.	Equipment and adequate fuel supply will have to be shipped to site. Activity will be limited to a construction season of about 3 months.	Excavation and cell construction will have to be completed during summer season of about 3 months.
- Reliability of technology	NA	NA	Limited schedule delays could result from equipment or supply problems with process operation at a remote location.	Technology is reliable, but equipment breakdowns at remote locations could cause delays.	Technology is reliable, but schedule delays could result from equipment and supply problems for such a remote location.
- Ease of undertaking additional remedial action if necessary	Contamination should dissipate with time.	Contamination should dissipate with time.	Limited soil excavation may be required at TPH "hot spots". Additional remediation could be implemented easily if required, but impact to tundra must be considered.	Once excavation and treatment has occurred, additional remedial action is unlikely, but may be implemented easily if required.	Once excavation and treatment has occurred, additional remedial action is unlikely, but may be implemented easily if required.
- Monitoring considerations	NA	Periodic soil, surface water, and groundwater sampling would be performed to measure natural attenuation processes	Annual soil sampling and groundwater sampling is proposed to evaluate biodegradation progress.	Confirmation sampling on excavation sidewalls and bottom will determine limits of excavation. Confirmation sampling will also be performed on treated soil. Groundwater should also be monitored to evaluate changes with source removal.	Confirmation sampling on excavation sidewalls and bottom will determine limits of excavation. Confirmation sampling will also be performed on treated soil. Groundwater should also be monitored for beach sands and gravels to evaluate changes with source removal.

TABLE 6-7. DETAILED ANALYSIS OF ALTERNATIVES FOR KOTZEBUE LRRS
(Page 4 of 4)

Evaluation Criteria	Alternative 1: No Action Pertaining to: Fill Material, Native Soil, Beach Sands and Gravels, Groundwater/Surface Water	Alternative 2: Access Restriction, Natural Attenuation/Monitoring Pertaining to: Fill Material, Native Soil, Beach Sands and Gravels, Groundwater/Surface Water	Alternative 3: *In Situ* Enhanced Biodegradation Pertaining to: Fill Material, Native Soil, Beach Sands and Gravels	Alternative 4: Excavation, Onsite Treatment by Thermal Washing Pertaining to: Fill Material, Beach Sands and Gravels	Alternative 5: Excavation, Onsite Enhanced Biodegradation Pertaining to: Fill Material, Beach Sands and Gravels
Implementability (Cont.)					
Administrative Feasibility					
- Coordination with other agencies	Coordinate with ADEC as lead agency, and address other comments after public review period.	Coordinate with ADEC as lead agency, and address other comments after public review period.	Coordinate with ADEC as lead agency, and address other comments after public review period.	Coordinate with ADEC as lead agency, and address other comments after public review period.	Coordinate with ADEC as lead agency, and address other comments after public review period.
Availability of Services and Materials					
- Availability of treatment, storage capacity, and disposal services	NA	NA	NA	NA	NA
- Availability of necessary equipment and specialists	NA	Equipment and specialists are available.	Equipment and specialists are available, but there may be a limited number of vendors experienced with tundra remediation.	There are a limited number of thermal washing systems available but this should not prevent implementation.	Equipment and specialists are available, but there may be a limited number of vendors experienced with servicing remote locations in Alaska.
Availability of Prospective Technologies	NA	NA	Availability of vendors with tundra remediation and Alaskan experience could limit the number of competitive bids.	Availability of thermal washing systems could limit the number of competitive bids.	Availability of vendors with Alaskan experience could limit the number of competitive bids.
Cost	None	Total cost for five-year monitoring of ground-water, surface water, soil and posting 20 signs $105,000	Fill Materials: $165,000 Native Soils: $135,000 Beach Sands and Gravels: $150,000 Overall cost for three Operable Units $275,000	Fill Materials: $2,524,000 Beach Sands and Gravels: $7,572,000	Fill Materials: $910,000 Beach Sands and Gravels: $1,970,000

TABLE 6-8. BASIS FOR COST ESTIMATES OF REMEDIAL ACTION ALTERNATIVES AT KOTZEBUE LRRS
(Cost estimates are based on maximum volume estimates for contaminated soil)
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ALTERNATIVE 1. NO ACTION

There are no costs associated with this alternative.

ALTERNATIVE 2. ACCESS RESTRICTION, NATURAL ATTENUATION MONITORING

The costs derived for this alternative are based on posting about 20 signs throughout the Kotzebue LRRS to restrict access. Monitoring will also be performed on an annual basis for a period of five years at which time the results will be evaluated to determine the need for continued monitoring.

Monitoring costs are based on collection of five surface soil samples from the beach sands and gravels, ten surface soil samples from the fill material and also from the native soils, six groundwater samples from existing monitoring wells, and five surface water samples. All samples will be analyzed for DROs and the groundwater samples will also be analyzed for BETX

Annual Monitoring Costs	$20,000
Installation of 20 Signs	$5,000
Total Cost for 5 Years	$105,000

ALTERNATIVE 3. *IN SITU* ENHANCED BIODEGRADATION

Costs for this alternative are based on an application rate of about four acres per four people a day. Individual costs have been developed for the beach sands and gravels, the fill material and the native soils. An overall cost to treat the three operable units is also provided, and it is more cost effective because of mobilization. Annual monitoring costs are also included to evaluate the alternatives effectiveness. Costs are based on an annual reapplication rate for five years at which time the effectiveness of the alternative will be evaluated.

Beach Sands and Gravels	
Assume treatment of five acres	$15,000
Annual monitoring of soil and groundwater	$15,000
Total Cost for 5 Years	$150,000
Fill Material	
Assume treatment of six acres	$18,000
Annual soil sampling	$15,000
Total Cost for 5 Years	$165,000
Native Soils	
Assume treatment of three acres	$12,000
Annual soil sampling	$15,000
Total Cost for 5 Years	$135,000
Overall Cost for three operable units	
Annual treatment cost	$35,000
Annual monitoring cost	$20,000
Total Cost for 5 Years	$275,000

TABLE 6-8. BASIS FOR COST ESTIMATES OF
REMEDIAL ACTION ALTERNATIVES AT KOTZEBUE LRRS
(Cost estimates are based on maximum volume estimates for contaminated soil)
(Page 2 of 2)

ALTERNATIVE 4. EXCAVATION, ONSITE TREATMENT BY THERMAL WASHING

The costs for this alternative are based on treating 16,000 yd^3 of fill material and 48,000 yd^3 of beach sands and gravels. Based upon the limited field season of about 3 months it will be assumed that a maximum of 8,000 yd^3 can be processed in one year. It is also assumed that the treated soil will be returned to the excavation and no clean fill will be required.

Beach Sands and Gravels	
Soil Excavation Costs 48,000 yd^3	$960,000
(Conversion factor 1 yd^3 = 1.7 tons)	
Soil Treatment Costs $70/ton	$5,712,000
Treatment Oversight and Confirmation Sampling	$900,000
Total Cost	$7,572,000
Fill Material	
Soil Excavation Costs 16,000 yd^3	$320,000
(Conversion factor 1 yd^3 = 1.7 tons)	
Soil Treatment Costs $70/ton	$1,904,000
Treatment Oversight and Confirmation Sampling	$300,000
Total Cost	$2,524,000

ALTERNATIVE 5. EXCAVATION, ONSITE ENHANCED BIOREMEDIATION

The volumes and assumptions presented for Alternative 4 also apply to this alternative. However, because the soil treatment will take over eight months, about 8,000 yd^3 of clean fill will be required for the first field season and the treated fill will be used from that point on. It is also assumed that there is enough indoor building space available to stockpile 8,000 yd^3 of soil in three foot lifts for bioremediation.

Beach Sands and Gravels	
Treatability Study	$100,000
Soil Excavation Costs 48,000 yd^3	$960,000
Provide 8,000 yd^3 of clean fill	$280,000
Berm Construction	$90,000
Bioremediation Treatment	$90,000
Excavation Oversight and Confirmation Soil Sampling	$450,000
Total Cost	$1,970,000
Fill Material	
Treatability Study	$100,000
Soil Excavation Costs 16,000 yd^3	$320,000
Provide 8,000 yd^3 of clean fill	$280,000
Berm Construction	$30,000
Bioremediation Treatment	$30,000
Excavation Oversight and confirmation soil sampling	$150,000
Total Cost	$910,000

ARARs will occur in time. This technology has proven to be effective in tundra environments, particularly because if its non-invasive approach.

6.5.1.4 ***Alternative 4, Excavation, Onsite Treatment by Thermal Washing.*** This alternative has been considered for fill material, and beach sands and gravels. As presented in Table 6-7, this alternative satisfies the seven criteria. However, the excavation process is very time consuming, because of the limited field season. In addition the costs are excessive, particularly for the beach sands and gravels. Hot air vapor extraction, and thermal desorption should also be considered for treatment of excavated soils if this technology progresses to the bidding phase. Technology is constantly improving, and competition among the vendors would ensure a more cost effective remediation.

6.5.1.5 ***Alternative 5, Excavation, Onsite Enhanced Biodegradation.*** This alternative has been considered for fill material, and beach sands and gravels. This alternative also satisfies the seven criteria. The time factor for success of this method is uncertain, and it may be determined by performing a treatability study which could consist of constructing a test cell in Kotzebue. Enhanced biodegradation appears to be more cost effective than thermal washing, but its success hinges upon treatment rates.

6.6 COMPARATIVE ANALYSIS

Summary Table 6-9 has been developed to provide a concise comparative review of the five remedial alternatives, and support the detailed analysis of remedial alternatives presented in Table 6-7. Only two alternatives, excavation with treatment by thermal washing or enhanced bioremediation satisfied the seven evaluation criteria for treatment of the fill material. All of the other alternatives had deficiencies with some of the criteria.

6.6.1 Beach Sands and Gravels

Severe climatic conditions and a limited construction season delay the effectiveness of some of the alternatives, particularly those involving excavation and treatment of the beach sands and gravels. Because of the large estimated volume (48,000 cubic yards) of contaminated sands and gravels, remediation would be performed over a period of three to six years. During this time natural attenuation will have reduced the petroleum hydrocarbon concentrations. The petroleum hydrocarbon contamination has

TABLE 6-9. COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES AT KOTZEBUE LRRS

Alternative	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long Term Effectiveness	Reduction of Toxicity Mobility and Volume	Short Term Effectiveness	Implementability	Cost
1. No Action							
Fill Material	○	○	○	○	○	●	$0
Beach Sands and Gravels	●	○	⊖	⊖	⊖	●	$0
Native Soils and Surface Water/Groundwater	●	⊖	⊖	⊖	⊖	●	$0
2. Access Restriction, Natural Attenuation, Monitoring							
Fill Material	⊖	○	○	○	○	●	$150,000[1]
Beach Sands and Gravels	●	○	⊖	⊖	⊖	●	$150,000[1]
Native Soils and Surface Water/Groundwater	●	⊖	⊖	⊖	⊖	⊖	$150,000[1]
3. In Situ Enhanced Biodegradation							
Fill Material	⊖	⊖	⊖	⊖	⊖	●	$165,000[2]
Native Soil	●	⊖	●	●	●	●	$135,000[2]
Beach Sands and Gravels	●	⊖	⊖	●	⊖	●	$150,000[2]
4. Excavation, Onsite Treatment by Thermal Washing							
Fill Material	●	●	●	●	●	●	$2,524,000
Beach Sands and Gravels	●	⊖	●	●	⊖	⊖	$7,572,000
5. Excavation, Onsite Enhanced Bioremediation							
Fill Material	●	●	●	●	●	●	$910,000
Beach Sands and Gravels	●	⊖	●	●	⊖	⊖	$1,970,000

1 Annual monitoring for period of 5 years.
2 Cost for all three operable units simultaneously 275,000.

○ Does not fulfill criteria.
⊖ Generally meets criteria.
● Meets criteria reasonably well.

decreased in the beach sands and gravels between sampling in 1989 and 1994 largely resulting from removal of the three above-ground fuel tanks as well as from natural attenuation. Because the source to the beach sands and gravel has been removed and free product was not detected during the RI sampling in 1994, a non-invasive method of remediation is more suitable for treatment of beach sands and gravels. The overall protection of human health and the environment is satisfied for the beach sands and gravels with the no action alternative. When comparing the other evaluation criteria for no action with those for the *in situ* enhanced biodegradation, and natural attenuation alternatives there is a general agreement. Therefore with the support of the baseline risk assessment results, the no action alternative is recommended for the beach sands and gravels.

6.6.2 Fill Material

Remediation of the fill material could be accomplished over two construction seasons, and excavation and treatment of some of this material is warranted. Unlike the beach sands and gravels, there are unacceptable risks for human health and the environment associated with the fill material. The uncertainties associated with *in situ* bioremediation make either thermal washing or *ex situ* bioremediation the alternatives of choice. Both of these methods meet the evaluation criteria, and the major differences between them are cost, and the time factor for the bioremediation process. A reasonable approach would be to construct a test cell for bioremediation evaluation in conjunction with limited excavation and soil treatment in areas of elevated hydrocarbon contamination. The methods of thermal washing, thermal desorption, and hot air vapor extraction should prove to be equally effective, and they should each be examined during the bidding process to determine which method would be the most cost effective.

6.6.3 Native Soils

There is very little variation of the evaluation criteria results among the first three alternatives for native soils. The risk assessment did not determine any unacceptable risks for native soils, and therefore all of the alternatives including no action are protective of human health and the environment. It is likely that *in situ* enhanced biodegradation would speed up the natural attenuation process, but a treatability study has not been performed. Based upon the remoteness of the site, the limited risk, and the uncertainties associated with enhanced bioremediation, the access restriction alternative with natural attenuation monitoring for native soils is recommended.

6.6.4 Surface Water/Groundwater

In evaluating the seven criteria as they pertain to groundwater and surface water, there is no difference between the first two alternatives. Neither groundwater nor surface water poses an unacceptable risk to both human health and the environment from fuel related contaminants. Water quality should improve with natural attenuation in the fill material, and therefore the access restriction alternative with monitoring is recommended for both surface water, and groundwater.

7.0 SUMMARY OF SITE STATUS AND RECOMMENDATIONS

This section provides a summary of the status and recommendations for the 19 sites and 5 areas of concern presently identified at Kotzebue LRRS (Table 7-1):

- Site SS01-Waste Accumulation Area No.1
- Site SS02-Waste Accumulation Area No.2/Landfill
- Site SD03-Road Oiling
- Site ST04-White Alice Tanks (AOC9)
- Site ST05-Beach Tanks
- Site SS06-Spill/Leak No.1
- Site SS07-Lake
- Site SS08-Barracks Pad
- Site SS09-PCB Spill
- Site SS10-Solvent Spill
- Site SS11-Fuel Spill
- Site SS12-Spills No.2 and 3
- Site SS13-Landfarm (AOC1)
- Site SS14-East Tanks (AOC3)
- Site SS15-Garage/Power Plant (AOC4)
- Site SS16-Navigational Aid Buildings (AOC6)
- Site SS17-Building 102 (AOC6)
- Site SS18-Truck Fill Stand (AOC11)
- Site SS19-PCB Spill South Fence (AOC12)
- AOC2-POL Line
- AOC5-Small Day Tanks
- AOC7-Steel Pilings
- AOC8-White Alice Garage
- AOC10-Septic Holding Tank

TABLE 7-1. SUMMARY OF SITE STATUS AND RECOMMENDATIONS FOR KOTZEBUE LRRS, ALASKA
(Page 1 of 4)

Site Designation	Site Description	Site Investigation	Remedial Actions Taken	Remaining Site Concerns	Site Recommendations
SS01-Waste Accumulation Area No. 1	The former location of an approximate 80 by 160 foot gravel pad used to store drummed waste oils and/or solvents.	1988 Stage 1 RI/FS; soil sampling.	1989 Excavation and removal of approximately 50 yd^3 of petroleum contaminated fill material.	None	Site closed, with concurrence from ADEC.
SS02-Waste Accumulation Area No. 2/Landfill	The former facility landfill and waste accumulation areas used to store and dispose of wastes at Kotzebue LRRS.	1994 RI; gradiometric survey, monitoring well installation, soil, surface water, and groundwater sampling.	None	Petroleum hydrocarbons (up to 5.5 mg/L) and pesticides detected at relatively low concentrations in shallow near-beach groundwater.	Consider regrading exposed surface debris with soil cover and revegetation of graded areas. Limited remedial action: monitoring of downgradient monitoring wells to evaluate potential contaminant migration from the site via groundwater to Kotzebue Sound.
SD03-Road Oiling	Waste oils, spent solvents, and other shop wastes were reportedly used for dust control on the installation's road system.	1988 Stage 1 RI/FS; soil sampling.	None	None	Site closed, with concurrence from ADEC.
ST04-White Alice Tanks (AOC9)	The location of two empty above-ground fuel storage tanks with an estimated capacity of 20,000 gallons each.	1994 RI; soil sampling.	None	Petroleum hydrocarbons (up to 2,900 mg/kg) in gravel fill materials.	Remedial action: excavation and onsite treatment of contaminated fill material .
ST05-Beach Tanks	The former location of three large above-ground fuel storage tanks used to store arctic-grade diesel fuel to heat and power the station.	1988 Stage 1 RI/FS; soil sampling. 1989 Stage 2 RI/FS; soil and groundwater sampling. 1994 RI; soil, groundwater, and seawater sampling, aquifer testing, tidal monitoring, natural attenuation assessment.	1992 Interim remedial action conducted by the USAF including the removal of the three above-ground storage tanks.	Petroleum hydrocarbons in beach sands and gravels (up to 18,000 mg/kg) and in near-beach groundwater (up to 34 mg/L).	Limited remedial action: natural attenuation and long-term groundwater monitoring.
SS06-Spill/Leak No. 1	Reported location of diesel fuel spill which occurred when a pipe coupling failed.	1987 Site Survey	None	None	Site closed, with concurrence from ADEC.
SS07-Lake	The lake formerly used as the facility's water supply source.	1988 Stage 1 RI/FS; surface water and sediment sampling 1994 RI; surface water, sediment, and soil sampling.	None	None	No action needed. Submit closure document to ADEC.
SS08-Barracks Pad	The location of a 25 by 40 foot gravel pad which was reportedly used to store facility chemicals such as solvents, rust inhibitors, and various fluorocarbons.	1988 Stage 1 RI/FS; soil sampling. 1994 RI; soil sampling.	None	Petroleum hydrocarbons (up to 33,000 mg/kg) in gravel fill material.	Remedial action: excavation and onsite treatment of contaminated fill material .

TABLE 7-1. SUMMARY OF SITE STATUS AND RECOMMENDATIONS FOR KOTZEBUE LRRS, ALASKA
(Page 2 of 4)

Site Designation	Site Description	Site Investigation	Remedial Actions Taken	Remaining Site Concerns	Site Recommendations
SS09-PCB Spill	The reported location of a PCB spill which covered an approximate 10 by 10 foot portion of gravel pad.	1988 Stage 1 RI/FS soil sampling.	1989 An estimated 5.3 yd^3 of PCB-contaminated soil was excavated and placed in 55 gallon drums and shipped to DRMO at Elmendorf, AFB, AK.	None	Site closed, with concurrence from ADEC.
SS10-Solvent Spill	The reported location where waste solvents were dumped at the White Alice Site.	1988 Stage 1 RI/FS; soil sampling.	1989 An estimated 9 yd^3 of PCB-contaminated soil was excavated and placed in 55 gallon drums and shipped to DRMO at Elmendorf, AFB, AK	None	Site closed, with concurrence from ADEC.
SS11-Fuel Spill	The reported location of a jet fuel spill which covered an approximate 50 by 60 foot area in native tundra.	1988 Stage 1 RI/FS; soil sampling. 1994 Stage 1 RI/FS; soil, sediment, and surface water sampling.	1989 *In situ* enhanced bioremediation pilot study conducted to reduce concentrations of petroleum hydrocarbons in site soil.	None	No action needed. Submit closure document to ADEC.
SS12-Spills No. 2 and No. 3	The site is comprised of two diesel fuel spill areas which have commingled. Spill No. 2 reportedly occurred in 1979-1980 when a day tank behind the facility's power plant was overfilled covering a 40 by 80 foot area in gravel fill. Spill No. 3 is an estimated 1.5 acre diesel fuel spill located adjacent to, and southwest of, the Composite Facility.	1988 Stage 1 RI/FS; soil and surface water sampling, soil gas survey, water flooding pilot studies. 1994 RI; soil and surface water sampling.	1989 Excavation and removal of approximately 100 yd^3 from Spill No. 2 and 350 yd^3 from Spill No. 3 of petroleum contaminated fill material. 1989-1990 An *in situ* enhanced bioremediation pilot study conducted to reduce petroleum hydrocarbon concentrations in soil.	Petroleum hydrocarbons in soil (up to 53,000 mg/kg) and in ponded surface water (up to 8.8 mg/L).	Remedial action (gravel fill): excavation and onsite treatment of contaminated fill material . Limited remedial action (native tundra): natural attenuation and long-term monitoring.
SS13-Landfarm (AOC1)	A landfarm was constructed during the 1989 Stage 2 RI/FS to remediate approximately 500 yd^3 of petroleum hydrocarbon contaminated soil at Kotzebue LRRS.	1989-1990 Stage 2 RI/FS; intermittent soil sampling to evaluate effectiveness. 1994 RI; soil and surface water sampling.	1989-1990 Approximately 500 yd^3 of petroleum hydrocarbon contaminated soil and fill were excavated from sites and placed in the landfarm cell. Soils were mixed with emulsification, and micronutrient agents.	Petroleum hydrocarbons in landfarm material (up to 5,100 mg/kg), in adjacent native soils (up to 4,800 mg/kg) and in ponded surface water at 2.0 mg/L.	Remedial action (gravel fill): excavation and onsite treatment of contaminated landfarm material. Limited remedial action (native tundra): natural attenuation and long-term monitoring.
SS14-East Tanks (AOC3)	The location of two large (approximately 20,000 gallons each), empty above-ground diesel fuel storage tanks.	1994 RI; soil sampling.	None	Petroleum hydrocarbons (up to 10,000 mg/kg) in gravel fill.	Remedial action: excavation and onsite treatment of petroleum hydrocarbon contaminated fill material.

TABLE 7-1. SUMMARY OF SITE STATUS AND RECOMMENDATIONS FOR KOTZEBUE LRRS, ALASKA
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Site Designation	Site Description	Site Investigation	Remedial Actions Taken	Remaining Site Concerns	Site Recommendations
SS15-Garage/Power Plant (AOC4)	The location of the garage and power plant located at the Composite Facility at Kotzebue LRRS.	1994 RI; soil sampling.	None	Petroleum hydrocarbons (up to 10,000 mg/kg) in gravel fill material.	Petroleum hydrocarbon contaminants at Site SS15 have commingled and should be incorporated with Site SS12. Remedial action: excavation and onsite treatment of petroleum hydrocarbon contaminated fill material.
SS16-Navigational Aid Buildings (AOC6)	The location of two navigational aid buildings (Buildings 101 and 102) at Kotzebue LRRS.	1994 RI; soil, sediment, and surface water sampling.	None	Petroleum hydrocarbons (up to 25,000 mg/kg) in gravel fill and (estimated 0.11 mg/L) in ponded surface water.	Remedial action: excavation and onsite treatment of petroleum hydrocarbon contaminated fill material.
SS17-Building 102 (AOC6)	The location of a 6 by 12 foot area of stained soil located in a gravel driveway at the Navigational Aid Building 102	1994 RI; soil sampling.	None	Petroleum hydrocarbons (up to 1,500 mg/kg) in gravel fill.	No further action. (The area of stained soil is currently incorporated in Site SS16.)
SS18-Truck Fill Stand (AOC11)	The location of a truck fill stand consisting of a 10 by 8 foot gravel pad approximately 5 feet thick.	1994 RI; soil sampling.	None	Petroleum hydrocarbons (up to 9,900 mg/kg) in gravel fill and (up to 67,000 mg/kg) in native soils.	Remedial action: excavation and onsite treatment of petroleum hydrocarbon contaminated fill material. Limited remedial action (native tundra): natural attenuation, and long-term monitoring.
SS19-PCB Spill South Fence (AOC12)	The location of a small (100 ft^2) but distinct area of stained gravel fill material west of the active radar dome.	1994 RI; soil sampling.	None	Petroleum hydrocarbons (up to 27,000 mg/kg) in gravel fill.	Remedial action: excavation and onsite treatment of petroleum hydrocarbon contaminated fill material.
AOC2-POL Line	The POL Line is a 2-inch diameter steel pipeline used to transport diesel fuel from the former beach fuel storage tanks to the Composite Facility.	1994 RI; soil sampling.	None	None	No action needed. No closure document required for area of concern.
AOC5-Small Day Tanks	This area of concern represents a number of small day tanks, which were formerly used throughout the installation for heating and equipment operation.	1994 RI; soil sampling.	None	Petroleum hydrocarbons detected in gravel fill and soil above the 1,000 mg/kg ADEC soil target level at nine day tank locations.	Remedial action: excavation and onsite treatment of petroleum hydrocarbon contaminated fill material.

TABLE 7-1. SUMMARY OF SITE STATUS AND RECOMMENDATIONS FOR KOTZEBUE LRRS, ALASKA
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Site Designation	Site Description	Site Investigation	Remedial Actions Taken	Remaining Site Concerns	Site Recommendations
AOC7-Steel Pilings	The location of several erected steel pilings. The site is the suspected location of the former construction camp established during the construction of the radar facility.	1994 RI; soil sampling.	None	None	No action needed. No closure document required for area of concern.
AOC8-White Alice Garage	The location of a garage facility located at the White Alice site.	1994 RI; soil sampling.	None	Petroleum hydrocarbons (up to 3,500 mg/kg) in soil and PCB Aroclor 1260 (up to 8.4 mg/kg) in fill materials.	Interim Remedial action: excavation and onsite treatment of petroleum hydrocarbon contaminated fill material.
AOC10-Septic Holding Tank	The septic holding tank was the primary treatment for domestic sewage and wastewater at Kotzebue LRRS. Septic tank effluent was discharged to Kotzebue Sound via an outfall line.	1994 RI; septic tank sludge sampling.	None	A sludge sample collected from the base of the septic tank revealed concentrations of volatile and semi-volatile compounds, pesticide and PCBs, and metals, which if released to the environment, may exceed established regulatory and/or risk-based criteria.	Further site assessment is recommended to determine if historical effluent discharge from the septic tank has impacted Kotzebue Sound at or near the outfall location. Removal and/or treatment of sludge material within the septic holding tank is recommended.

ADEC = Alaska Department of Environmental Conservation.

(AOC9) = Indicates site was previously identified as an area of concern.

The information for each site and area of concern includes: 1) a summary which describes the site, identifies remaining concerns, and provides specific recommendations; 2) a description which identifies the site, its location, and environmental setting; 3) an IRP investigation summary which identifies past and recent activities conducted at the site; 4) the identification of remaining concerns based on an evaluation of state and federal ARARs and risk-based criteria developed during the 1994 RI; and 5) site recommendations based on IRP investigation information, applicable ARARs and risk based-criteria, and feasibility study results.

7.1 SITE SSO1-WASTE ACCUMULATION AREA NO. 1

7.1.1 Summary of Site Status

Site SS01-Waste Accumulation Area No. 1 is the former location of an approximate 80 by 160-foot gravel pad used to store drummed waste oils and/or solvents. Petroleum hydrocarbons (up to 16,200 mg/kg) in soil was the primary environmental concern at the site. During the 1989 Stage 2 RI/FS, approximately 50 cubic yards of petroleum hydrocarbon contaminated fill material were excavated from the site. The excavated soils were deposited in a near-by landfarm cell designed to bioremediate petroleum contaminated fill material at the installation. Clean backfill was placed in the excavation and graded to conform with the surrounding topography. Excavation and removal of the contaminated fill materials effectively remediated site soil and the USAF issued a Final No Further Action Decision Document for Site SS01 in July 1991. ADEC concurred with the No Further Action alternative for Site SS01 in correspondence to the USAF dated December 1991. The USAF and ADEC consider Site SS01 closed.

7.1.2 Site Description

Site SS01 is located approximately 500 feet south of the Composite Facility, west of the installation access road (Figure 7-1). The site is situated approximately 125 ft above sea level and is the former location of an approximate 80 by 160-foot gravel pad used to store drummed waste oils and/or solvents. Permafrost was encountered from 2.8 to 6.3 feet below ground surface (USAF 1990a). No surface water is evident at the site and no shallow suprapermafrost water was encountered (USAF 1990a). The site exhibits relatively poor drainage, with local surface runoff directed toward the southwest, based on general site topography (see Figure 7-1).

7.1.3 IRP Investigation Summary

In 1988, a Stage 1 RI/FS was conducted at Kotzebue LRRS including the installation of 15 hand auger soil borings at Site SS01 (USAF 1990b). The soil borings were screened using a photoionization detector (PID) to identify the presence of total volatile organic compounds. Based on field screening results, four soil samples were collected and submitted for analysis of petroleum hydrocarbons (Method 418.1 E), volatile organic compounds (Method SW 8240), semivolatile organic compound (Method SW 8270), organochlorine pesticides and PCBs (Method SW 8080), and total metals (Method SW 6010 series). A summary of maximum detected concentrations is provided in Section 3.2, Stage 1 RI/FS; Table 3-3.

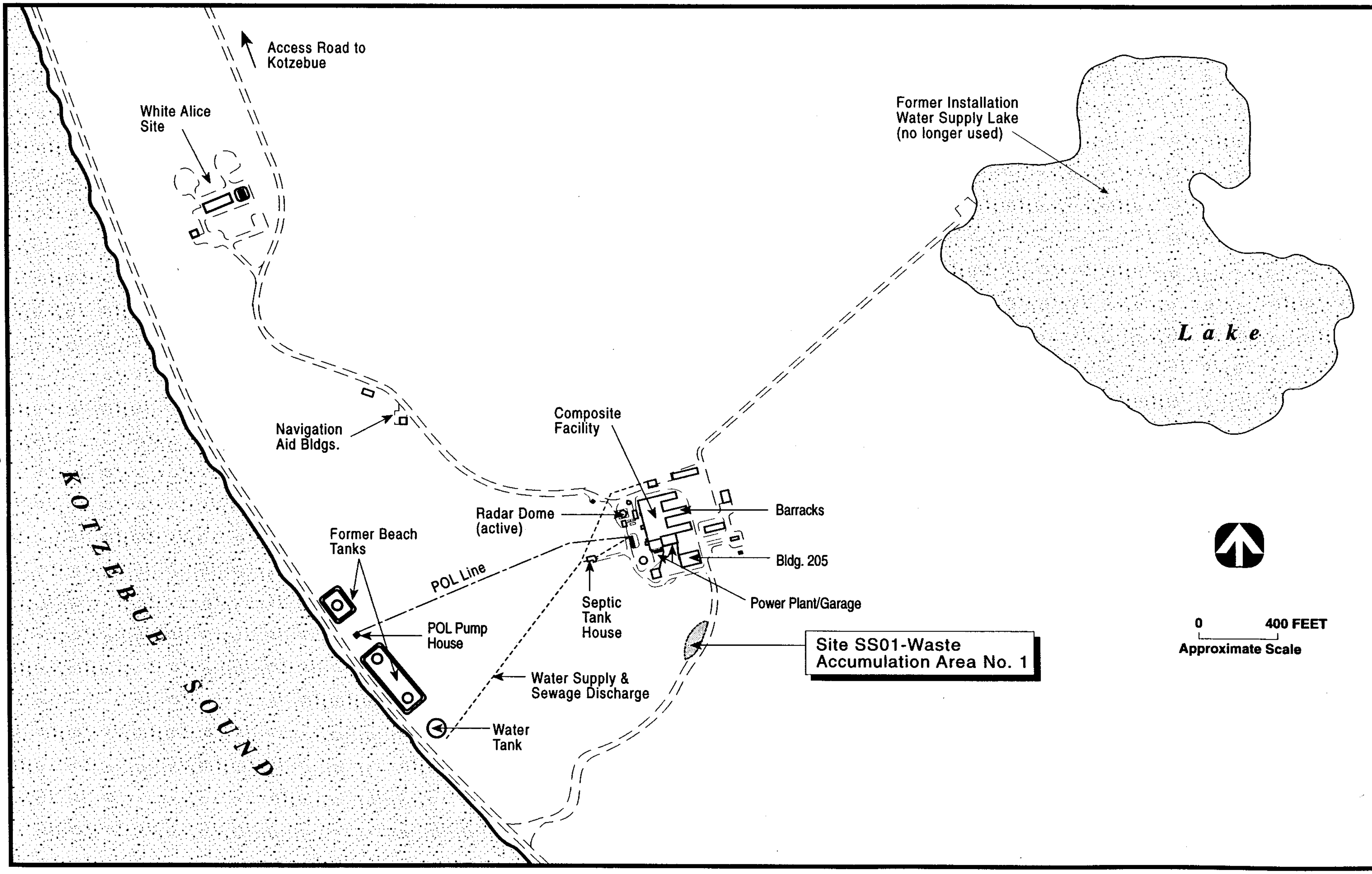


Figure 7-1. Location of Site SS01-Waste Accumulation Area No. 1, Kotzebue LRRS, Alaska.

Due to the detection of petroleum hydrocarbons in soil at a maximum concentration of 16,200 mg/kg, a remedial action was conducted in 1989 which included the excavation of approximately 50 cubic yards of petroleum contaminated fill material from Site SS01 (USAF 1990b). The contaminated fill material was removed from the site and placed in a near-by landfarm cell constructed to bioremediate petroleum hydrocarbon contaminated fill materials at the installation. The effectiveness of the cleanup was evaluated by field screening with a PID. Clean backfill was deposited in the excavation and graded to conform to the surrounding topography (USAF 1990b).

7.1.4 Remaining Site Concerns

The excavation and removal of petroleum hydrocarbon contaminated fill material effectively remediated site soils based on results from field screening with a PID conducted during the remedial action. There are no remaining environmental concerns at Site SS01.

7.1.5 Site Recommendations

The USAF issued a Final No Further Action Decision Document for Site SS01 in July 1991 (USAF 1991). ADEC concurred with the No Further Action alternative for Site SS01 in correspondence to the USAF dated December 1991 (ADEC 1991b). The USAF and ADEC consider Site SS01 closed.

7.2 SITE SS02-WASTE ACCUMULATION AREA NO.2/LANDFILL

7.2.1 Summary of Site Status

Site SS02-Waste Accumulation Area No. 2/Landfill is comprised of a waste accumulation area and facility landfill, formerly used to store and dispose of wastes at Kotzebue LRRS. Petroleum hydrocarbons (up to 5.5 mg/L) and pesticides detected at relatively low concentrations in shallow near-beach groundwater are the primary contaminants identified at the site. The USAF cleaned and graded Site SS02 in 1975. However, the former landfill site currently exhibits intermittent areas of mounding that include landfill debris (e.g., metal wastes such as crushed drums and containers and other metallic debris). The observed mounding is suspected to comprise the buried wastes previously described to be remaining at the site. Although landfill debris identified at Site SS02 is not suspected to pose a significant threat to human health or the environment, regrading of exposed metallic debris at Site SS02 should be considered and should include soil cover and revegetation of graded areas to restore the site.

Based on the limited nature and levels of contaminants detected in soil, surface water, and groundwater, and a review of associated ARARs and baseline risk assessment information, no significant environmental or human health concerns are currently present at the site. However, a gradiometric survey conducted at Site SS02 indicated a potential for buried metallic debris (i.e., other than observed mounded areas) within the former landfill. Although the gradiometric survey results are qualitative and do not specifically indicate a potential risk, limited remedial action is recommended at Site SS02 through groundwater monitoring of downgradient wells to evaluate potential contaminant migration from the site via groundwater to Kotzebue Sound.

7.2.2 Site Description

Site SS02 is located approximately 0.25 miles west of the Composite Facility along the beach area adjacent to Kotzebue Sound (Figure 7-2). The site is comprised of a waste accumulation area and landfill, formerly used to store and dispose of wastes at Kotzebue LRRS. The Waste Accumulation Area No.2 was located northwest of the former beach fuel tanks and adjacent (south) of the installation landfill. The waste accumulation area was used to store a variety of waste from base operations; however, information regarding specific types and quantities of wastes stored at the site were not identified. The waste accumulation area was reportedly used until 1972 (USAF 1985). The installation landfill was located on a triangular piece of land adjacent to the waste accumulation area, northwest of the former fuel

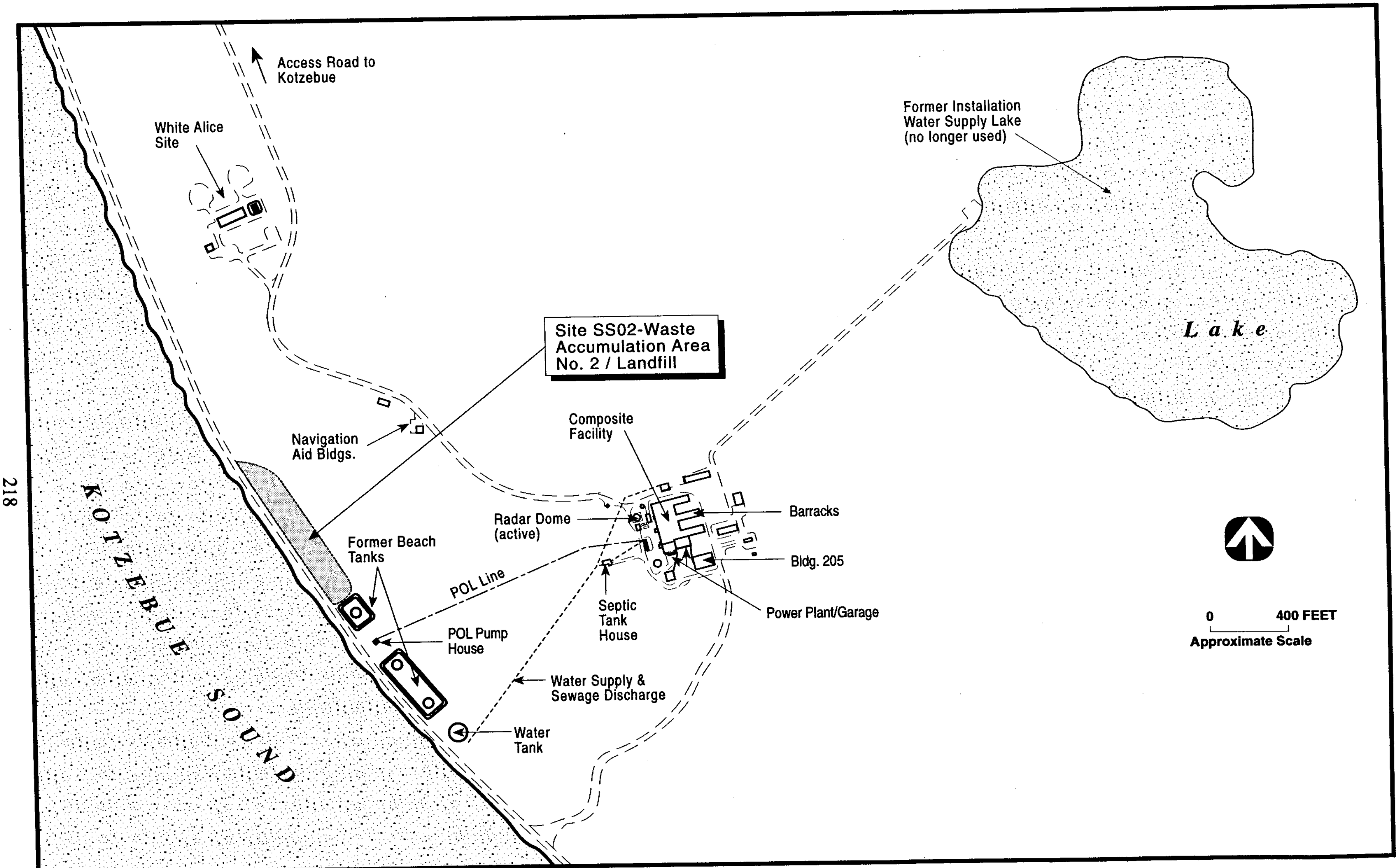


Figure 7-2. Location of Site SS02-Waste Accumulation Area No. 2 / Landfill, Kotzebue LRRS, Alaska.

storage tanks on the beach (see Figure 7-2). The landfill was used to dispose of facility wastes until approximately 1974; burning of wastes occurred on a regular basis (USAF 1985). In 1975, the landfill and waste accumulation area were cleaned up. The wastes that were stored in drums in the waste accumulation area were shipped to the Defense Reutilization and Marketing Office (DRMO) at Elmendorf AFB, Alaska, for disposal. Petroleum-based wastes in drums that were leaking were used for dust control on the facility's road system. Empty drums were disposed of in the community landfill. The ground in the vicinity of the landfill and the waste accumulation area was graded during the cleanup. Although most wastes were removed during the cleanup, some wastes remaining at the landfill were reportedly buried (USAF 1985).

The shallow near-beach aquifer system underlying Site SS02 consists of unconsolidated sediments, approximately 13 feet thick. The upper portion of the aquifer (approximately 0-5 ft below ground surface) is typically comprised of gravelly sand/sandy gravel beach terrace deposits. The base of the aquifer is defined by a massive (competent) silty clay confining layer, at approximately 13 feet below grade. The relatively shallow silty clay confining layer encountered at the site has been described as a 60-foot thick marine blue clay deposit (Cederstrom 1961). A sequence of graded storm deposits is present between the upper gravel terrace deposits and lower bounding silt/clay, which serves as a confining layer for shallow contamination. Near-beach groundwater typically occurs between 3 and 4 feet below ground surface along the steepened beach face immediately adjacent to Kotzebue Sound, and from 6 to 7 feet below ground surface within the landfill area. The local groundwater flow direction is estimated to be to the southwest, toward Kotzebue Sound. The estimated groundwater flow rate in the vicinity of the site is approximately 17 feet per year (see Section 4.6.2, Slug Test Results).

The near-beach groundwater at Kotzebue LRRS is saline (brackish) in nature, is tidally influenced, and represents a non-potable resource. Recharge of the near-beach aquifer system is likely controlled by the highly seasonal nature of the active zone (suprapermafrost water) inputs that recharge the beach area from the tundra uplands (see Section 4.6.3, Tidal Monitoring Results).

7.2.3 IRP Investigation Summary

In 1987, a survey was conducted at Site SS02. The site was reported as revegetated with no visual signs of surface contamination (e.g., no signs of staining or stressed vegetation). Site SS02 was excluded from the 1988 RI/FS investigation based on the 1975 cleanup and regrading of the site, and the results of the

1987 site reconnaissance (USAF 1990a). The USAF recommended no further action at Site SS02 in a Final No Further Action Decision Document dated July 1991 (USAF 1991). However, due to reported wastes buried within the landfill, ADEC requested further information regarding specific types, quantities, and estimated depths for any wastes buried at the site (ADEC 1991a). No additional information was found regarding the remaining wastes at the former installation landfill.

In 1993, a site survey was conducted of Kotzebue LRRS and the surrounding area, including the former landfill and waste accumulation area. The former landfill area exhibited intermittent areas of mounding that contained landfill debris, including metal wastes such as drums and other empty containers and debris. The buried wastes previously described to be remaining in the landfill were suspected to comprise the mounding observed during the 1993 site survey.

Site SS02 was characterized during the 1994 RI, including a gradiometric survey to evaluate lateral extent of buried metallic debris, groundwater sampling to evaluate potential contaminant migration to Kotzebue Sound, non-invasive sampling to characterize site soil, and surface water sampling within the landfill area to characterize the potential for contaminants leaching from the site (Figure 7-3). During the 1994 field investigation, a tar disposal trench was discovered within Site SS02 and an interim remedial action (IRA) was conducted to mitigate potential imminent hazards associated with the disposal trench. Table 7-2 provides a summary of 1994 field investigation activities conducted at Site SS02. A summary of maximum detected concentrations identified at Site SS02 is provided in Section 4.5, Summary of Analytical Results; Tables 4-12 through 4-21. All sample analytical results for the 1994 RI are provided in Appendix L.

*7.2.3.1 **Monitoring Well Installation.*** During the 1994 RI, three shallow groundwater monitoring wells were installed in downgradient locations at Site SS02, to facilitate an evaluation of potential contaminant migration via groundwater (see Figure 7-3). A detailed description of monitoring installation and development at Kotzebue LRRS is provided in Section 4.4.4, Monitoring Well Installation and Development). Monitoring well completion diagrams for Wells SS02-MW1, MW2, and MW3 are provided in Appendix B.

*7.2.3.2 **Gradiometric Survey.*** A gradiometric survey was conducted at Site SS02 during the 1994 RI to identify the presence or absence of buried metallic objects and their location. A detailed description

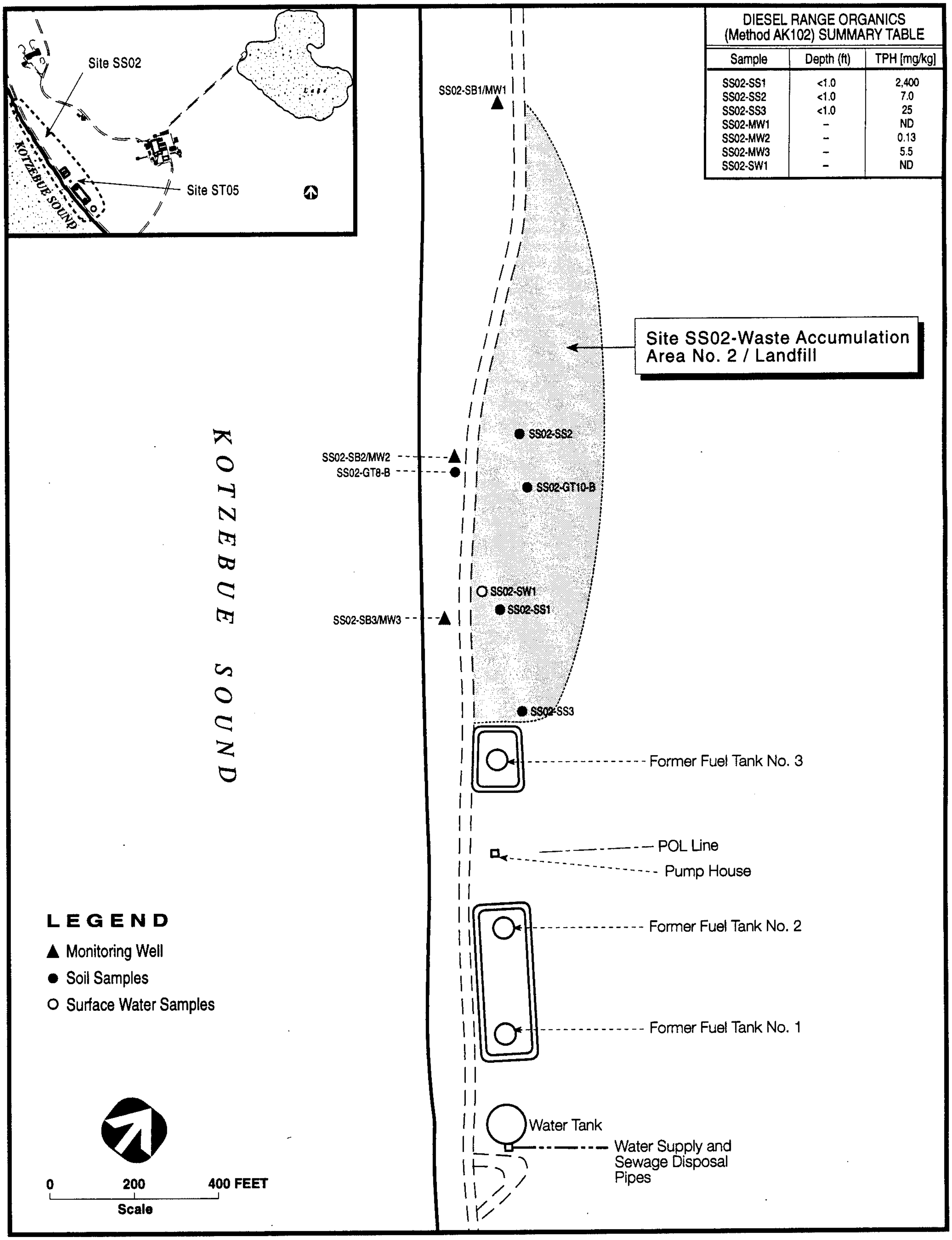


Figure 7-3. Location of Monitoring Wells and Sample Stations at Site SS02-Waste Accumulation Area No. 2 / Landfill, 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

TABLE 7-2. 1994 SUMMARY REMEDIAL INVESTIGATION ACTIVITIES SUMMARY FOR SITE SS02, KOTZEBUE LRRS, ALASKA

Field Sampling	Analyses Performed	Field Activities
3 Surface Soil Samples	(3) Diesel Range Organics (Method AK102) (1) Residual Range Organics (Method AK102-Extended) (3) Volatile Organic Compounds (EPA Method SW8260) (3) Semivolatile Organic Compounds (EPA Method SW8270) (3) Pesticides and PCBs (EPA Method SW 8081) (3) Metals (EPA 6010 series; 7000 series for lead and mercury)	■ All sample locations surveyed ■ Three monitoring wells were installed to evaluate downgradient groundwater quality ■ A gradiometric survey was conducted to identify the presence or absence of buried metallic objects and their locations ■ An interim remedial action was conducted to remove tar and associated soil materials from a tar disposal trench discovered during the 1994 field investigation
3 Groundwater Samples	Diesel Range Organics (Method AK102) Volatile Organic Compounds (EPA Method SW8260) Semivolatile Organic Compounds (EPA Method SW8270) Pesticides and PCBs (EPA Method SW 8081) Metals (EPA 6010 series; 7000 series for lead and mercury)	
1 Surface Water Sample	Diesel Range Organics (Method AK102) Volatile Organic Compounds (EPA Method SW8260) Semivolatile Organic Compounds (EPA Method SW8270) Pesticides and PCBs (EPA Method SW 8081) Metals (EPA 6010 series; 7000 series for lead and mercury)	
2 Geotechnical Samples	Soil Permeability (Constant-head; ASTM Method D5084) Grain Size Distribution (ASTM C136 and D422) Total Organic Carbon (EPA Method 9060)	

of the gradiometric survey is provided in Section 4.4.8, Gradiometric Survey. Qualitative results of the gradiometric survey are presented in Section 4.6.5, Gradiometric Survey Results; Figure 4-10. Appendix F provides gradiometric survey descriptions on a grid-specific basis. The gradiometric survey indicated the potential detection of significant buried metallic material in limited areas (grid cells) of the landfill. However, it is important to note that magnetic locators are very susceptible to noise caused by some natural soil conditions and are limited in providing quantitative data concerning the number and depth of identified targets. This survey should be viewed as a qualitative method of identifying locations which may or may not contain buried metallic wastes such as drums.

7.2.3.3 Interim Remedial Action. During the 1994 RI, a tar disposal trench was discovered within the former installation landfill. Initial reconnaissance of the site identified a 3 by 9 foot area, approximately 1 foot deep, consisting of a black, tarry substance of unknown composition. The carcasses of two ground squirrels were observed trapped in the substance.

An Interim Remedial Action (IRA) was immediately initiated to characterize and excavate the material that was exposed to human and wildlife contact (see Section 4.4.13, Interim Remedial Action). The IRA was conducted in two phases, and included the excavation, removal and containment of approximately 1,433 gallons of tar-laden soil, 850 gallons of tar product, and 17 empty, partially crushed 55-gallon drums. Toxicity Characteristics Leaching Procedure (TCLP) analyses were conducted of the tar-like substance to evaluate its chemical properties. Analytical results indicated that the substance was not a hazardous material based on toxicity. The tar-like substance is believed to be asphalt "cut back" used during the construction of the asphalt pads which supported the three large fuel tanks formerly located along the beach area to the west of the main radar facility. Two soil samples were collected from the base of the excavation at the completion of the removal action. These samples were analyzed for total petroleum hydrocarbons, and the effectiveness of the cleanup was verified when no residual contamination was detected in either sample.

7.2.4 Remaining Site Concerns

Table 7-3 provides a summary of state and federal regulatory criteria (ARARs) and risk-based criteria exceeded in the three media sampled at Site SS02: soil, groundwater, and surface water. State and federal ARARs established to guide the 1994 RI are discussed in Section 4.2, Applicable or Relevant and Appropriate Requirements.

TABLE 7-3. 1994 REMEDIAL INVESTIGATION SUMMARY OF IRP CLEANUP CRITERIA EXCEEDANCE AT SITE SS02-WASTE ACCUMULATION AREA NO. 2/LANDFILL, KOTZEBUE LRRS, ALASKA

ARAR[a] Exceedance				Risk Based Exceedance[e]					
				Human Health					Ecological
Media	Chemical of Concern	Sample Concentration	ARAR Criteria	Media	Pathway	Chemical of Concern	Sample Concentration	Health-Based Criteria	
Soil	Diesel Range Organics	2,400 mg/kg	1,000 mg/kg[b]	Soil	Ingestion	Arsenic	7 mg/kg	4.74	No unacceptable risks were estimated
					Inhalation	Arsenic	7 mg/kg	4.61	
Surface Water	4,4'-DDE	0.065 μg/L	0.0059 μg/L[c]	No unacceptable risks were estimated					No unacceptable risks were estimated
	4,4'-DDD	0.045 μg/L	0.0083 μg/L[c]						
	4,4'-DDT	0.039 μg/L	0.0059 μg/L[c]						
Groundwater	Total PAHs	17 μg/L	15 μg/L[d]	No unacceptable risks were estimated					No unacceptable risks were estimated
	4,4'-DDE	0.074 μg/L	0.0059 μg/L[c]						
	4,4'-DDD	0.057 μg/L	0.0083 μg/L[c]						
	4,4'-DDT	0.400 μg/L	0.0059 μg/L[c]						
	Diesel Range Organics	5.5 mg/L	0.015 mg/L[d]						

[a] Applicable or relevant and appropriate requirements.

[b] Alaska Department of Environmental Conservation; Petroleum hydrocarbon target level of 1,000 mg/kg for soils at Kotzebue LRRS.

[c] Federal Water Quality Criteria (State's compliance); protection of human health from the consumption of contaminated water, fish, and/or shellfish (U.S. EPA 1992, Federal Register Vol. 57, No. 246).

[d] Alaska Department of Environmental Conservation; Water Quality Standards Regulations (18 AAC 70; January 1995).

[e] Ecological and human health risk-based criteria established using 1994 Remedial Investigation results (USAF 1995b).

7.2.4.1 Soil. A total of three surface soil samples were collected from Site SS02 (see Table 7-2). One surface soil sample (SS02-SS1) indicated diesel range organics detected at 2,400 mg/kg. Sample SS02-SS1 was collected adjacent to the former tar disposal trench to characterize nearby soils. Sample SS02-SS1 was selected to measure residual range organics to evaluate the heavier petroleum constituents associated with asphaltic material. The original AK102 extract was reanalyzed (within method-specific holding time) using an extended AK102 method to quantify residual range organics between C28 through C40. Results indicate a significant increase in residual range organics concentration at 31,000 mg/kg, as compared to diesel range organics measured in the same sample. The IRA (excavation and removal action) conducted at the tar disposal trench encompassed the soil where SS02-SS1 was collected. Confirmation soil samples collected at the conclusion of the IRA indicated that no residual contamination remained at this location on the landfill. In support of the 1994 remedial investigation, a baseline risk assessment was conducted (USAF 1995b). No unacceptable ecological risks were estimated for Site SS02 soil (USAF 1995b). The baseline risk assessment indicates a potential risk to human health (i.e., $> 10^{-6}$ risk) for soil ingestion (1.48E-6) and inhalation of airborne dust (2.14E-6) pathways based on the detection of arsenic in site soil. Arsenic was detected in surface soil Sample SS02-SS1 at 5 mg/kg, SS02-SS2 at 6 mg/kg, and SS02-SS3 at 7 mg/kg, slightly exceeding the threshold concentration of 4.74 mg/kg for soil ingestion pathway. The inhalation pathway represents exposure values from the entire installation because it assumes that an individual could be exposed to airborne dust anywhere on the site. Although Site SS02 surface soil samples exceed health-based threshold criteria for arsenic (i.e., 4.61 mg/kg for inhalation pathway), the concentrations in Site SS02 soil are less than the arithmetic mean concentration of arsenic measured in background samples (i.e., 27 mg/kg). No known sources of arsenic are identified for Site SS02, and the detection of arsenic in background locations indicate this element is naturally occurring. The average concentration of arsenic in natural soils is reportedly 5 mg/kg, but can range from 1 mg/kg to 50 mg/kg (EPA 1983).

7.2.4.2 Surface Water. A single surface water sample (SS02-SW1) was collected from an area of ponded water approximately 10 by 15 feet and approximately 2 feet deep within the former landfill (see Table 7-2). The pesticides 4,4'-DDE, 4,4'-DDD, and 4,4'-DDT were detected at relatively low concentrations at 0.065 μg/L, 0.045 μg/L, and 0.039 μg/L, respectively (e.g., at or near laboratory practical quantitation limits). However, these concentrations exceed federal water quality criteria of 0.0059 μg/L for 4,4'-DDE, 0.0083 μg/L for 4,4'-DDD, and 0.0059 μg/L for 4,4'-DDT, established for the State of Alaska, based on the protection of human health from the consumption of contaminated water, fish,

and/or shellfish (EPA 1992; see Table 7-3). No unacceptable ecological or human health risks were estimated for surface water at Site SS02, including the potential risks associated with contaminant migration to Kotzebue Sound (USAF 1995b). Because ponded water at Site SS02 is limited in extent, does not represent a potential drinking water source for humans, reveals no unacceptable human or ecological risks, and indicates relatively low concentrations of identified pesticides, no remedial action is warranted.

7.2.4.3 Groundwater. Three groundwater samples were collected from monitoring wells (SS02 MW1, MW2, and MW3) installed in downgradient locations between Site SS02 and Kotzebue Sound to facilitate an evaluation of potential contaminant migration via groundwater (see Figure 7-3). Diesel range organics were detected in Site SS02 groundwater samples at concentrations of 0.13 mg/L and 5.5 mg/L collected from monitoring wells MW2 and MW3, respectively, during the 1994 RI. Due to the relatively shallow nature of the near-beach aquifer system at Kotzebue LRRS and its proximity to Kotzebue Sound, ADEC considers the beach area at Kotzebue LRRS (including the shallow near-beach groundwater system) regulated under Water Quality Standards Regulations (see Section 4.2, Applicable or Relevant and Appropriate Requirements). The concentration of DROs in monitoring wells MW2 and MW3 exceed the 0.015 mg/L ADEC Water Quality Standard for petroleum hydrocarbons in surface water (ADEC 1995). The source of DROs in groundwater is suspected to be Site ST05-Beach Tanks, which is located immediately south of well MW3 and has revealed elevated soil and groundwater DROs concentrations (see Figure 7-3). Natural attenuation processes, including biodegradation, will act to reduce remaining concentrations of DROs in site groundwater (see Section 4.6.6, Natural Attenuation Assessment Results).

Pesticide compounds were ubiquitously detected at relatively low concentrations during the 1994 RI, including at all background soil sample locations (see Section 4.6.7, Background Characterization Results). The pesticides 4,4'-DDE, 4,4'-DDD, and 4,4'-DDT were detected at relatively low concentrations at 0.074 μg/L, 0.057 μg/L, and 0.40 μg/L, respectively (e.g., at or near laboratory practical quantitation limits) in a single groundwater sample (SS02-MW2). However, these concentrations exceed federal water quality criteria of 0.0059 μg/L for 4,4'-DDE, 0.0083 μg/L for 4,4'-DDD, and 0.0059 μg/L for 4,4'-DDT, established for the State of Alaska, based on the protection of human health from the consumption of contaminated water, fish, and/or shellfish (EPA 1992; see Table 7-3). No unacceptable ecological or human health risks were estimated for groundwater at Site SS02 (USAF 1995b). Potential groundwater exposure pathways considered for humans include: ingestion of water, dermal contact with

water, or inhalation of chemicals volatilized from water. The potable water supply for the Kotzebue LRRS comes from the City of Kotzebue. Therefore, ingestion of groundwater is not a potential exposure pathway at the site. Both dermal contact with groundwater and inhalation due to volatilization were considered to be exposure pathways of low significance due to climatic conditions at Kotzebue and the unlikelihood of groundwater surfacing at the site.

Because the shallow near-beach aquifer system is not a potable drinking water source (i.e., brackish), DROs and pesticides were detected at relatively low concentrations, and no risk-based criteria were exceeded at the site, no remedial action is warranted.

7.2.5 Site Recommendations

Site SS02-Waste Accumulation Area No. 2/Landfill is comprised of a waste accumulation area and facility landfill, formerly used to store and dispose of wastes at Kotzebue LRRS. Petroleum hydrocarbons (up to 5.5 mg/L) and pesticides detected at relatively low concentrations in shallow near-beach groundwater are the primary contaminants identified at the site. The USAF cleaned and graded Site SS02 in 1975. However, the former landfill site currently exhibits intermittent areas of mounding that include landfill debris (i.e., metal wastes such as crushed drums and containers and other metallic debris). The observed mounding is suspected to comprise the buried wastes previously described to be remaining at the site. Although landfill debris identified at Site SS02 is not suspected to pose a significant threat to human health or the environment, regrading of exposed metallic debris at Site SS02 should be considered and should include soil cover and revegetation of graded areas to restore the site.

Based on the limited nature and levels of contaminants detected in soil, surface water, and groundwater, and a review of associated ARARs and baseline risk assessment information, no significant environmental or human health concerns are currently present at the site. However, a gradiometric survey conducted at Site SS02 indicated a potential for buried metallic debris (i.e., other than observed mounded areas) within the former landfill. Although the gradiometric survey results are qualitative and do not specifically indicate a potential risk, limited remedial action is recommended at Site SS02 through groundwater monitoring of downgradient wells. Groundwater monitoring is recommended on a biannual basis for a duration of 4 years (i.e., two biannual monitoring events) and should include volatile organics, semivolatile organics, pesticides and PCBs, diesel range organics, and metals analyses collected from site monitoring wells (i.e., Monitoring wells SS02-MW1, MW2, and MW3) to evaluate potential contaminant

migration from the site via groundwater to Kotzebue Sound. The limited duration of monitoring at Site SS02 is recommended based on: 1) the site was cleaned and has been inactive for approximately 20 years, and 2) no significant environmental or human health concerns were identified based on recent site characterization. Data obtained from biannual groundwater monitoring should be reviewed for compliance with ARARs and to evaluate the nature, extent, and levels of contaminants as compared to previously detected concentrations at Site SS02.

7.3 SITE SDO3-ROAD OILING

7.3.1 Summary of Site Status

Waste oils, spent solvents, and other shop wastes were reportedly used for dust control on the installation road systems. The use of waste oil for dust control was practiced until 1984. Site SD03-Road Oiling was characterized during the 1988 Stage 1 RI/FS and was found not to exceed established cleanup criteria or to show significant risk (USAF 1990a). In July 1991, the USAF submitted a Final No Further Action Decision Document for Site SD03. ADEC concurred with the No Further Action alternative for the site in correspondence to the USAF dated November 1991. The USAF and ADEC currently consider Site SD03 closed.

7.3.2 Site Description

Site SDO3 is comprised of the installation road system and the area immediately adjacent to it, and extends several thousand linear feet (Figure 7-4). Waste oils, spent solvents, ethylene glycol, and other shop wastes were applied to the road for dust control and waste oil disposal until 1984.

7.3.3 IRP Investigation Summary

Site SD03 was characterized during the 1988 Stage 1 RI/FS by advancing three shallow soil borings to approximately 1.5 ft below ground surface in the northern, central, and southern portions of the site. A soil sample was collected from each of the three borings and submitted for analysis of petroleum hydrocarbons (Method 418.1 E), volatile organic compounds (Method SW 8240), organochlorine pesticides and PCBs (Method SW 8080), and total metals (Method SW 6010 series). A summary of maximum detected concentrations is provided in Section 3.2, Stage 1 RI/FS; Table 3-3. All sample locations were surveyed for elevation and horizontal coordinates.

7.3.4 Remaining Site Concerns

No significant risk or exceedance of established cleanup criteria were identified at Site SD03 during the 1988 Stage 1 RI/FS. There are no remaining environmental concerns associated with Site SD03.

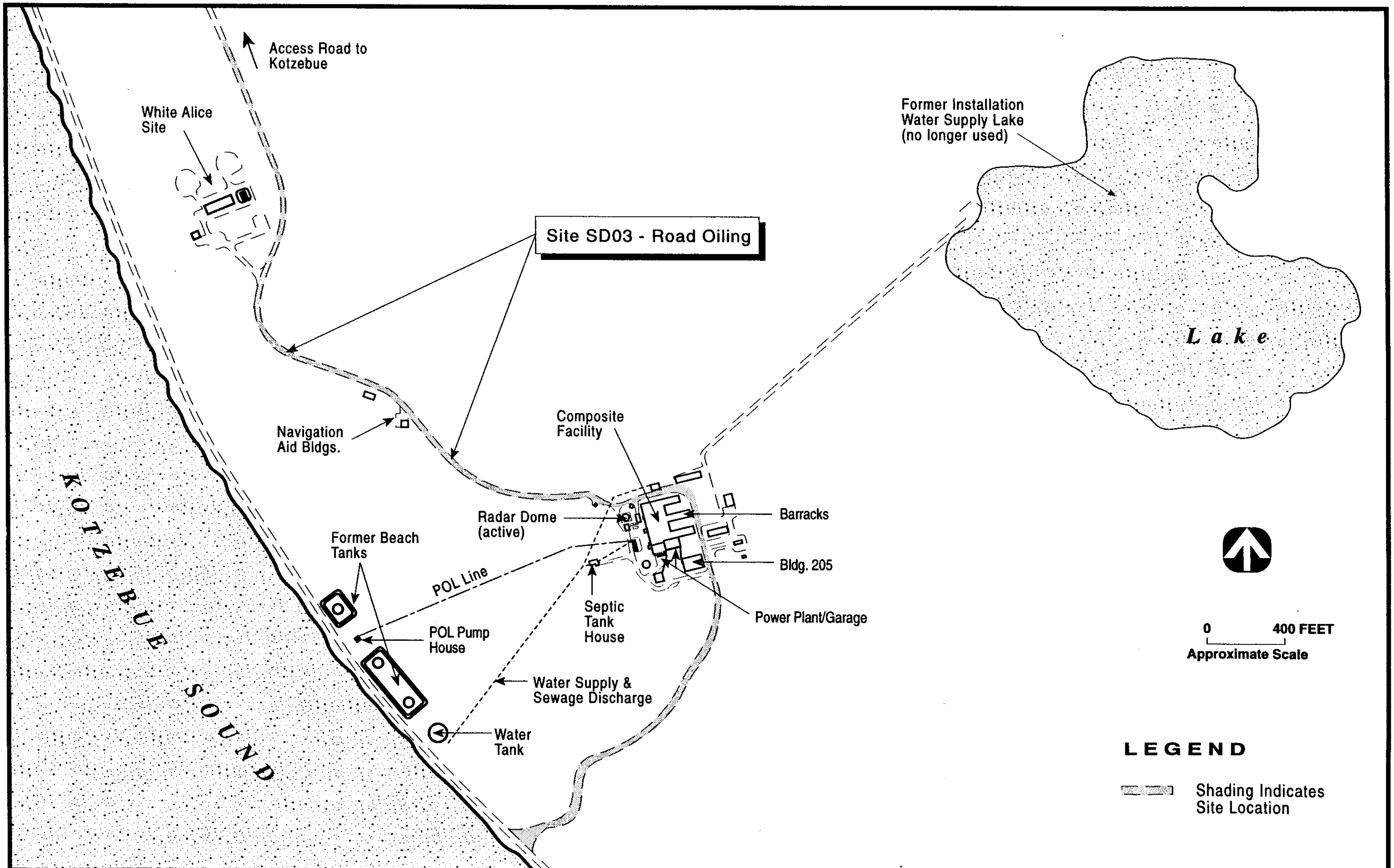


Figure 7-4. Location of Site SD03-Road Oiling, Kotzebue LRRS, Alaska.

7.3.5 Site Recommendations

The USAF issued a Final No Further Action Decision Document for Site SD03 in July 1991 (USAF 1991). ADEC concurred with the No Further Action alternative for Site SD03 in correspondence to the USAF dated December 1991 (ADEC 1991b). The USAF and ADEC currently consider Site SD03 closed.

7.4 SITE ST04-WHITE ALICE TANKS (AOC9)

7.4.1 Summary of Site Status

Site ST04-White Alice Tanks (AOC9) is the location of two above-ground storage tanks located at the White Alice Site, adjacent to Building 1001. Petroleum hydrocarbons in gravel fill material (up to 2,900 mg/kg) is the primary environmental concern identified at the site. It is recommended that remedial action be implemented, involving the decommissioning of the two above-ground storage tanks and the excavation and removal of contaminated fill materials which currently exceed the ADEC soil target level of 1,000 mg/kg. Onsite treatment of contaminated fill materials is recommended to reduce petroleum hydrocarbon concentrations to acceptable levels for onsite disposal of treated soils.

7.4.2 Site Description

Site ST04 is located at the White Alice Site, approximately 0.5 miles northwest of the Composite Facility (Figure 7-5). The site is the location of two above-ground diesel fuel storage tanks, with an estimated capacity of 20,000 gallons each, located adjacent to Building 1001. The tanks are presently empty, and tank piping has been disconnected. The tanks are contained within a gravel berm area and are supported above a gravel base by concrete footings. A drain pipe (conduit) drains the northeast corner of the bermed enclosure. The tanks appear to be in good condition, with no observable signs of deterioration. The tanks were identified as a new area of concern (AOC9) based on reports of leaking at tank outlet valves. Later the site designator was changed to ST04.

Frozen ground was encountered at relatively shallow depths (e.g., 2 feet below ground surface) at the gravel fill/native soil contact during a site investigation. The site shows relatively poor drainage; however, surface water accumulation within the bermed area is drained to the east in native tundra via a drainage conduit. The gravel pad supporting the tanks is estimated to be 5 feet thick.

7.4.3 IRP Investigation Summary

In 1993, a site survey of the Kotzebue LRRS and surrounding areas was conducted to evaluate current site conditions, identify potential areas of concern, and obtain the information necessary to prepare RI/FS scoping documents in preparation for the 1994 IRP activities. During the site survey, some signs of soil staining were observed directly beneath tank outlet valves at Site ST04. The tanks were determined to be empty at the time of inspection and appeared to be in good condition with no signs of deterioration.

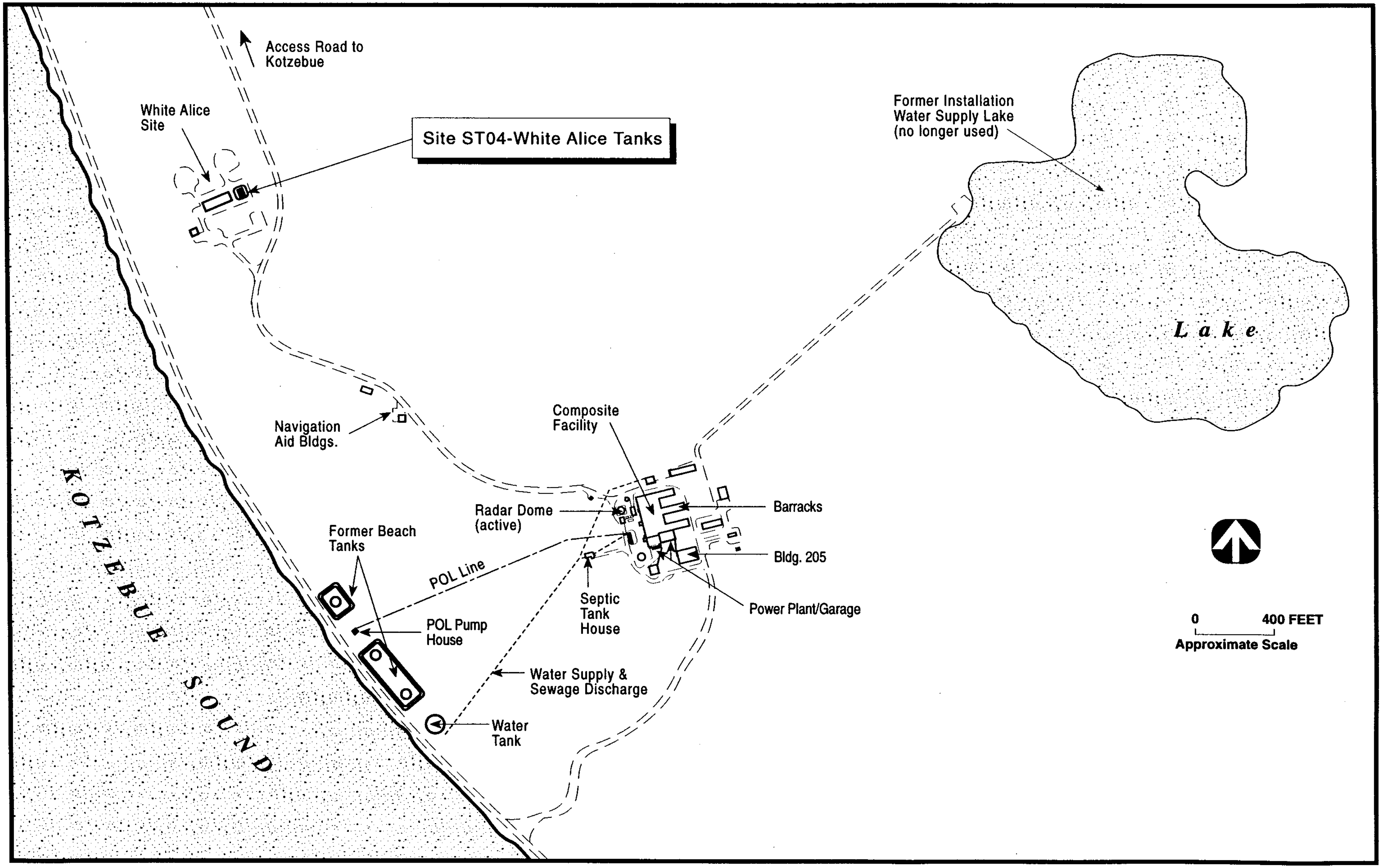


Figure 7-5. Location of Site ST04-White Alice Tanks, Kotzebue LRRS, Alaska.

The site was included for investigation based on reports of leaking tank outlet valves and signs of localized soil staining beneath these valves.

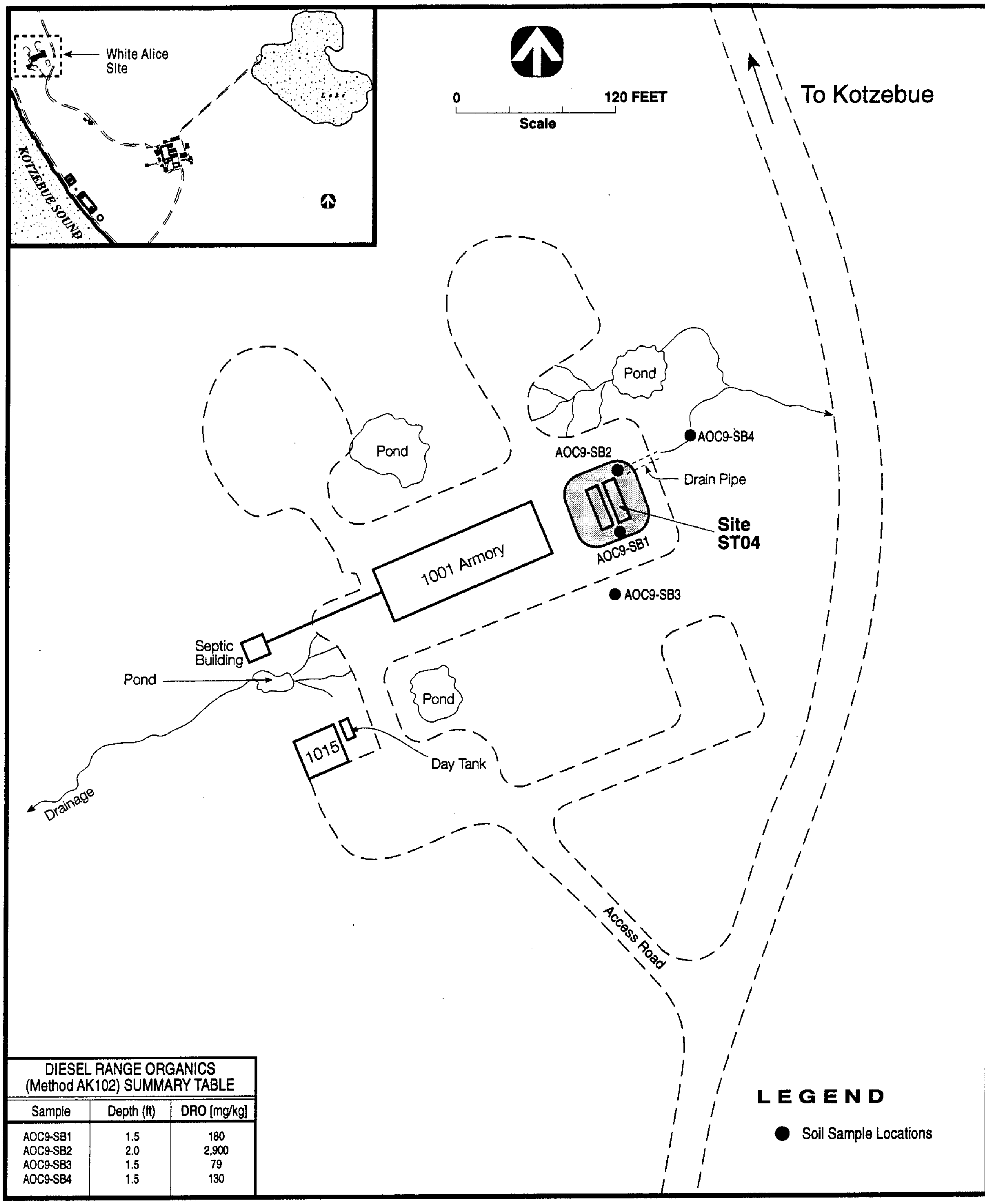
Site ST04 was initially characterized during the 1994 RI by advancing three shallow soil borings to approximately 2 feet below ground surface in gravel fill material (Figure 7-6). A soil sample was collected from each boring and analyzed for diesel range organics (Method AK 102), volatile organic compounds (EPA Method SW 8260), semivolatile organic compounds (EPA Method SW 8270), and pesticides and PCBs (EPA Method SW 8081). A fourth shallow subsoil sample was collected from native tundra (near the discharge point of the berm drain pipe) and analyzed for diesel range organics (see Figure 7-6). A summary of maximum detected concentrations is provided in Section 4.5, Summary of Analytical Results; Tables 4-12 through 4-21. All sample analytical results for the 1994 RI are provided in Appendix L. All sample locations were surveyed for elevation and horizontal coordinates (see Appendix C).

7.4.4 Remaining Site Concerns

No unacceptable ecological or human health risks were estimated for soils at Site ST04. One soil sample (AOC9-SB2) contained diesel range organics at 2,900 mg/kg, exceeding the 1,000 mg/kg ADEC target level for soils at Kotzebue LRRS (see Figure 7-6). No detections of VOCs, SVOCs, or pesticides and PCBs in soils exceed applicable ARARs or baseline risk criteria established for Kotzebue LRRS (see Section 4.2, Applicable or Relevant and Appropriate Requirements).

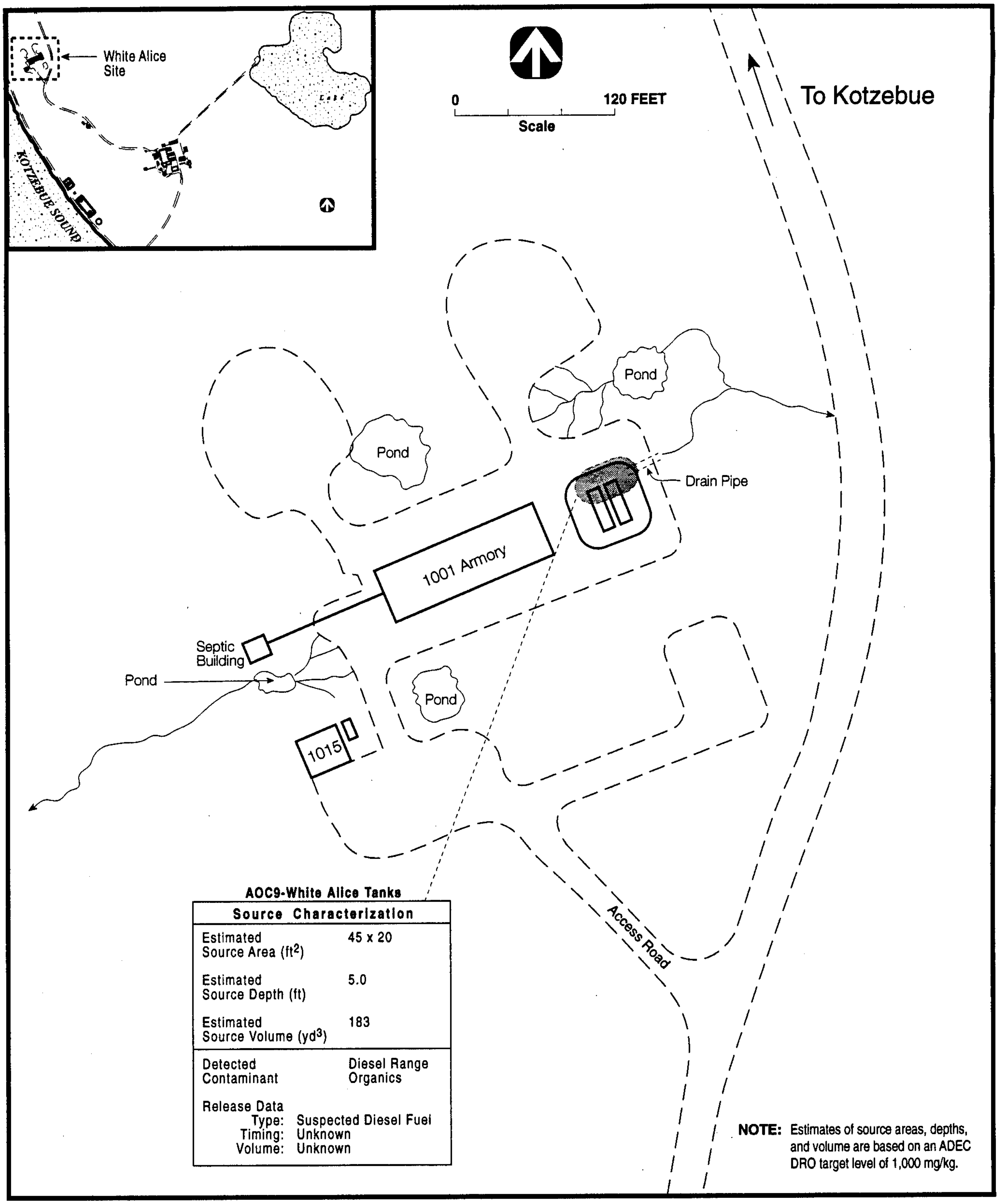
7.4.5 Site Recommendations

It is recommended that the two above-ground storage tanks located at the White Alice Site be decommissioned. It is also recommended that the contaminated fill materials which currently exceed the ADEC soil target level of 1,000 mg/kg be excavated, removed, and treated onsite. The estimated 183 cubic yards of contaminated material at or above the 1,000 mg/kg ADEC soil target level are located in an area 45 by 20 feet, with a depth of 5 feet (Figure 7-7).



DIESEL RANGE ORGANICS (Method AK102) SUMMARY TABLE		
Sample	Depth (ft)	DRO [mg/kg]
AOC9-SB1	1.5	180
AOC9-SB2	2.0	2,900
AOC9-SB3	1.5	79
AOC9-SB4	1.5	130

Figure 7-6. Location of Sample Stations at Site ST04-White Alice Tanks (AOC9), 1994 Remedial Investigation, Kotzebue LRRS, Alaska.



Source Characterization	
Estimated Source Area (ft^2)	45 x 20
Estimated Source Depth (ft)	5.0
Estimated Source Volume (yd^3)	183
Detected Contaminant	Diesel Range Organics
Release Data Type: Timing: Volume:	 Suspected Diesel Fuel Unknown Unknown

Figure 7-7. DRO Contaminant Source Characterization at Site ST04–White Alice Tanks (AOC9), 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

7.5 SITE ST05-BEACH TANKS

7.5.1 Summary of Site Status

Site ST05-Beach Tanks is the former location of three large above-ground fuel storage tanks located along the beach area adjacent to Kotzebue Sound. The fuel storage tanks were used to store arctic-grade diesel fuel to heat and power the station. Petroleum hydrocarbons in soil (up to 18,000 mg/kg) and in near-beach groundwater (up to 34 mg/L) are the primary environmental concerns at the site. Based on past IRP activities conducted at Site ST05, the remaining levels of contaminants, and a review of associated ARARs and baseline risk assessment, limited remedial action is recommended at Site ST05, including natural attenuation and long-term groundwater monitoring to evaluate potential contaminant migration to Kotzebue Sound and measure the effectiveness and rate of natural attenuation. The natural attenuation and long-term monitoring alternative represents a non-invasive, non-destructive alternative to material removal actions or other approaches that would negatively impact the beach area and local ecosystem at Kotzebue LRRS.

7.5.2 Site Description

Site ST05 is located approximately 0.25 miles west of the Composite Facility along the beach area adjacent to Kotzebue Sound (Figure 7-8). The site is the former location of three above-ground fuel storage tanks used to store arctic-grade diesel fuel to heat and power the station. Two of the storage tanks were 50 feet in diameter and 22 feet high, each with an estimated capacity of 7,890 barrels. The third storage tank was 44 feet in diameter and 24 feet high, with an estimated capacity of 6,500 barrels (USAF 1990b). In 1992, the USAF removed the three fuel storage tanks from the site. Only the tank nests (bermed containment areas), asphalt tank pads within the bermed areas, and the fuel pumphouse remain at the site. The site comprises an area of approximately 250 feet by 900 feet (see Figure 7-8).

7.5.2.1 Site Use. Recreation at and adjacent to Site ST05 includes all terrain vehicle use, summer picnicking and wading along the beach areas, beachcombing, and subsistence hunting and fishing. Additionally, the near-beach area of Kotzebue Sound is used for commercial fishing of chum salmon (USAF 1993).

7.5.2.2 Hydrogeology. The shallow near-beach aquifer system underlying Site ST05 consists of unconsolidated sediments, approximately 13 feet thick. The upper portion of the aquifer (approximately 0-5 ft

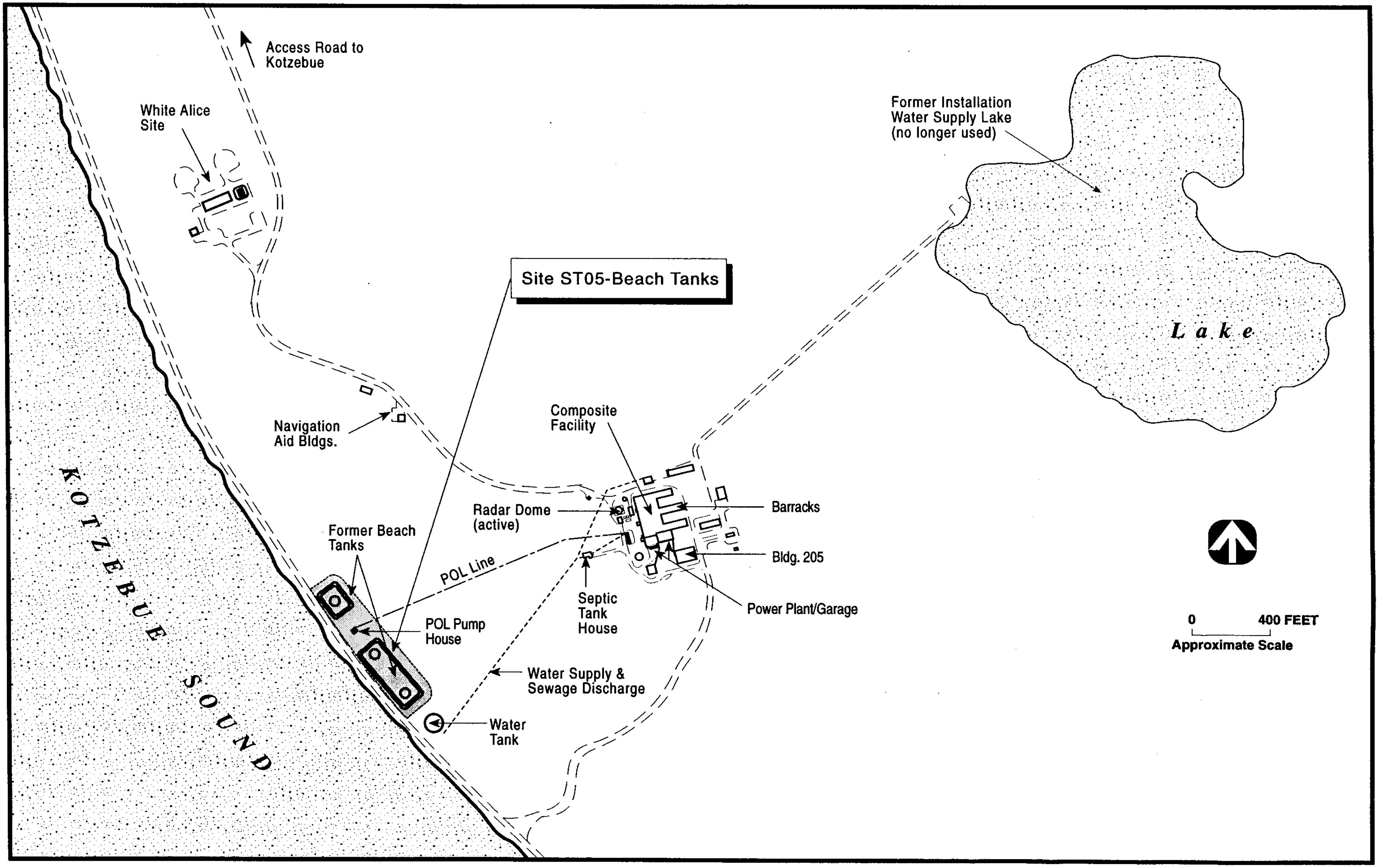


Figure 7-8. Location of Site ST05-Beach Tanks, Kotzebue LRRS, Alaska.

below ground surface) is typically comprised of gravelly sand/sandy gravel beach terrace deposits. The base of the aquifer is defined by a massive (competent) silty clay confining layer, approximately 13 feet below grade. The relatively shallow silty clay confining layer encountered at the site has been described as a 60-foot thick marine blue clay deposit (Cederstrom 1961). A sequence of graded storm deposits is present between the upper gravel terrace deposits and lower bounding silt/clay, which serves as a confining layer for shallow contamination. Near-beach groundwater typically occurs between 3 and 4 feet below ground surface along the steepened beach face immediately adjacent to Kotzebue Sound, and from 6 to 7 feet below ground surface within the landfill area. The local groundwater flow direction is estimated to be to the southwest, toward Kotzebue Sound. The estimated groundwater flow rate in the vicinity of the site is approximately 17 feet per year (see Section 4.6.2, Slug Test Results).

The near-beach groundwater at Kotzebue LRRS is saline (brackish) in nature, is tidally influenced, and represents a non-potable resource. Recharge of the near-beach aquifer system is likely controlled by the highly seasonal nature of the active zone (suprapermafrost water) inputs that recharge the beach area from the tundra uplands (see Section 4.6.3, Tidal Monitoring Results).

7.5.3 IRP Investigation Summary

Table 7-4 provides a summary of IRP activities conducted at Site ST05. During the 1988 Stage 1 RI/FS, six shallow subsoil samples were collected at Site ST05 (see Section 3.2, Stage 1 RI/FS; Table 3-3 for a summary of maximum detected concentrations). Due to the detection of petroleum hydrocarbons in soil at a maximum concentration of 5,300 mg/kg during the 1988 Stage 1 RI/FS, additional remedial investigation was conducted at Site ST05 during the 1989-1990 Stage 2 RI/FS (USAF 1990b).

The Stage 2 RI/FS included the installation of 28 test pits and the collection of 24 soil samples, 9 groundwater samples, and product samples from each of the above-ground storage tanks at Site ST05 (see Table 7-4). In addition, three piezometers were installed at Site ST05 to measure hydraulic conductivity and gauge tidal influence (USAF 1990b). The results of the 1989-1990 Stage 2 RI/FS indicated that elevated petroleum hydrocarbon concentrations remained in site soil at a maximum concentration of 21,000 mg/kg and in groundwater at 8,700 mg/L (see Section 3.3, Stage 2 RI/FS; Table 3-6 for a summary of maximum detected concentrations). In 1990, each of the beach storage tanks were gauged, estimating the cumulative diesel fuel remaining in the tanks to be approximately 39,500 gallons. Based on the results of the Stage 2 RI/FS, remedial action was recommended at Site ST05 including the

TABLE 7-4. SUMMARY OF IRP ACTIVITIES CONDUCTED AT SITE ST05-BEACH TANKS, KOTZEBUE LRRS, ALASKA
(Page 1 of 2)

Field Sampling	Analyses Performed	Field Activities
1988 Stage 1 RI/FS		
6 Soil Samples	Petroleum Hydrocarbons (EPA Method E 418.1) Volatile Organic Compounds (EPA Method SW 8240)	■ Three sample locations were surveyed ■ Eight test pits were installed ■ One hand auger boring advanced
1989-1990 Stage 2 RI/FS		
24 Soil Samples	(24) Petroleum Hydrocarbons (EPA Method E 418.1) (4) Semivolatile Organic Compounds (EPA Method SW 8270) (2) Microbial Enumeration (Total, Viable, and Phenanthrene-specific) (2) Constant Head Permeability Tests	■ All sample locations were surveyed ■ 28 test pits were installed ■ Three piezometers installed to evaluate hydraulic conductivity and tidal influence ■ Beach tanks gauged and sampled
9 Groundwater Samples	(9) Petroleum Hydrocarbons (Method E 418.1) (9) Purgeable Aromatics (EPA Method SW 8020) (5) Semivolatile Organic Compounds (EPA Method SW 8270) (9) Specific Conductance (Field Test) (9) Temperature (Field Test) (9) pH (Field Test) (3) Biological Oxygen Demand (EPA Method E 405.1) (3) Chemical Oxygen Demand (EPA Method E 410.4) (3) Total Dissolved Solids (EPA Method E 160.1) (7) Microbial Enumeration (Total, Viable, and Phenanthrene-specific)	
3 Tank Product Samples	NF	
1992 USAF Interim Remedial Action		
None	None	■ Interim remedial action conducted by USAF included the removal of three large above-ground beach fuel storage tanks

TABLE 7-4. SUMMARY OF IRP ACTIVITIES CONDUCTED AT SITE ST05-BEACH TANKS, KOTZEBUE LRRS, ALASKA
(Page 2 of 2)

Field Sampling	Analyses Performed	Field Activities
1994 Remedial Investigation		
27 Soil Samples	(24) Diesel Range Organics (Method AK102) (1) Residual Range Organics (Method AK102-Extended) (11) Volatile Organic Compounds (EPA Method SW 8260) (11) Semivolatile Organic Compounds (EPA Method SW 8270) (3) Pesticides and PCBs (EPA Method SW 8081)	■ All sample and monitoring well locations were surveyed ■ Nine monitoring wells were installed to evaluate groundwater quality ■ 24 shallow hollow stem auger borings were installed to evaluate soil and groundwater quality ■ A free product assessment was conducted in monitoring wells installed at the site ■ A tidal monitoring assessment was conducted in monitoring wells installed at the site ■ Falling and rising head slug tests were conducted in monitoring wells to estimate hydraulic conductivity ■ A natural attenuation assessment was conducted for both soil and groundwater at the site
1 Geotechnical Sample	Soil Permeability (ASTM Method D 5084) Grain Size Distribution (ASTM C136 and D442) Total Organic Carbon (EPA Method 9060)	
9 Groundwater Samples	(9) Diesel Range Organics (Method AK102) (9) Volatile Organic Compounds (EPA Method SW 8260) (9) Semivolatile Organic Compounds (EPA Method SW 8270) (9) Specific Conductivity (Field Measurement) (9) pH (Field Measurement) (8) Geochemical Parameters: Alkalinity, Nitrate Ammonia, Phosphate Chloride, Sulfate Carbon Dioxide, Sulfide (8) Dissolved Oxygen (8) Total Metals Fe/NA/CA/K/Mg (EPA Method 6010) (8) Total Organic Carbon (EPA Method 9060)	

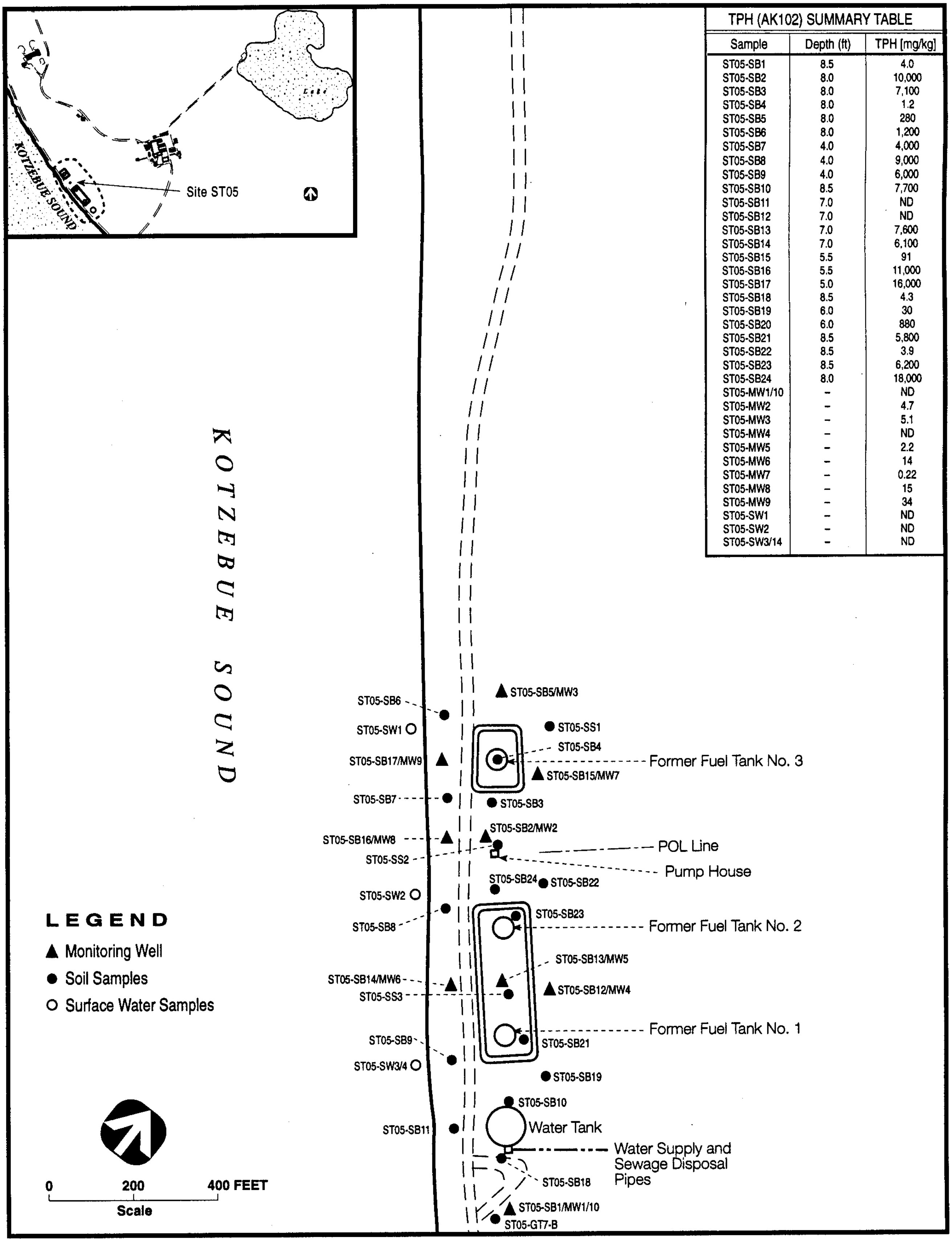
[a] NF = Not Found. No analytical parameters or sample results were identified in previous investigation reports (USAF 1990b).

mitigation of soil and groundwater contamination through *in situ* bioremediation without groundwater recapture (USAF 1990b). However, ADEC indicated that prior to conducting remedial activities at Site ST05, cleanup goals should be established for both beach soil and groundwater (ADEC 1992).

In 1992, an interim remedial action was conducted at Site ST05 when the three diesel fuel storage tanks were removed from the site. Only the tank nests (bermed containment areas), asphalt tank pads within the bermed area, and the fuel pumphouse remain at the site. In 1993, ADEC indicated concerns regarding Site ST05, stating that potential ongoing hazardous substance release to Kotzebue Sound may represent violations of Alaska statutes and regulations. ADEC further requested notification regarding remedial action work plans for Kotzebue LRRS in correspondence to the USAF dated May 1993 (ADEC 1993).

A comprehensive site characterization was conducted at Site ST05 during the 1994 RI, including soil, groundwater, and seawater sampling to evaluate current site conditions and potential contaminant migration to Kotzebue Sound; aquifer testing to estimate critical aquifer characteristics; tidal monitoring to determine the influence of tides on the near-beach groundwater system; and a natural attenuation assessment including both beach soil and groundwater to determine if natural attenuation process are actively occurring at the site (see Table 7-4). A summary of maximum detected concentrations identified at Site ST05 is provided in Section 4.5, Summary of Analytical Results; Tables 4-12 through 4-21. All sample analytical results for the 1994 RI are provided in Appendix L. Figure 7-9 provides the location of the 1994 RI sampling stations at Site ST05.

7.5.3.1 Soil Boring Installation. During the 1994 RI, 24 shallow soil borings were installed using a track-mounted hollow-stem auger drill rig equipped with 4.25-inch inside diameter (i.d.) hollow-stem augers. Borings were advanced using standard drill-and-drive techniques. Standard penetration tests were recorded for each sample drive in blows per 6 inches. A registered geologist supervised all drilling and well installation, and prepared lithologic logs of borings using the Unified Soil Classification System (USCS). Undisturbed soil samples were collected using the Standard Penetration Test procedure split-spoon method. Sample material was selected for laboratory analysis from zones of obvious contamination and based on field screening information. Boring logs for soil borings installed at Site ST05 are provided in Appendix A.



TPH (AK102) SUMMARY TABLE

Sample	Depth (ft)	TPH [mg/kg]
ST05-SB1	8.5	4.0
ST05-SB2	8.0	10,000
ST05-SB3	8.0	7,100
ST05-SB4	8.0	1.2
ST05-SB5	8.0	280
ST05-SB6	8.0	1,200
ST05-SB7	4.0	4,000
ST05-SB8	4.0	9,000
ST05-SB9	4.0	6,000
ST05-SB10	8.5	7,700
ST05-SB11	7.0	ND
ST05-SB12	7.0	ND
ST05-SB13	7.0	7,600
ST05-SB14	7.0	6,100
ST05-SB15	5.5	91
ST05-SB16	5.5	11,000
ST05-SB17	5.0	16,000
ST05-SB18	8.5	4.3
ST05-SB19	6.0	30
ST05-SB20	6.0	880
ST05-SB21	8.5	5,800
ST05-SB22	8.5	3.9
ST05-SB23	8.5	6,200
ST05-SB24	8.0	18,000
ST05-MW1/10	-	ND
ST05-MW2	-	4.7
ST05-MW3	-	5.1
ST05-MW4	-	ND
ST05-MW5	-	2.2
ST05-MW6	-	14
ST05-MW7	-	0.22
ST05-MW8	-	15
ST05-MW9	-	34
ST05-SW1	-	ND
ST05-SW2	-	ND
ST05-SW3/14	-	ND

Figure 7-9. Location of Monitoring Wells and Sample Stations at Site ST05-Beach Tanks, 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

7.5.3.2 Monitoring Well Installation. During the 1994 RI, shallow groundwater monitoring wells were installed in nine of the 24 boreholes advanced at Site ST05 to estimate the extent of groundwater contamination, provide representative and reproducible groundwater samples for aquifer characterization, and to evaluate the groundwater potentiometric surface (see Figure 7-9). Six additional deeper wells were to be installed to evaluate the physical and chemical characteristics of the aquifer at depth for Site ST05; however, frozen ground encountered at relatively shallow depths in the forebeach well locations, and the presence of a silty clay confining layer encountered at approximately 13 feet below ground surface, preempted the installation of the deeper wells. A detailed description of monitoring installation and development at Kotzebue LRRS is provided in Section 4.4.4, Monitoring Well Installation and Development. Monitoring well completion diagrams for Site ST05 are provided in Appendix B.

7.5.3.3 Aquifer Characterization. Near-beach aquifer parameters, including horizontal hydraulic gradients, groundwater flow rate and direction, and hydraulic conductivity were measured at Site ST05 during the Kotzebue LRRS 1994 RI. Hydraulic gradients and groundwater flow direction were determined using water level measurements in monitoring wells. Hydraulic conductivity was estimated by conducting falling and rising head slug tests in selected monitoring wells (i.e., ST05-MW4, MW5, and MW6). Groundwater flow rates were established based on hydraulic gradient measurements and hydraulic conductivity estimates (see Section 4.6.2, Slug Test Results). In general, groundwater flows toward the southwest with the flowlines perpendicular to Kotzebue Sound and groundwater discharging to the sound as would be expected. Hydraulic gradients were calculated at an average 0.004 feet per foot. The average hydraulic conductivity estimated from slug tests is 2.88 feet per day. Groundwater flow is estimated at approximately 17 feet per year, based on hydraulic gradient and conductivity estimates.

7.5.3.4 Free Product Assessment. During the 1994 RI, each monitoring well was investigated for the presence of free petroleum hydrocarbons no sooner than two days after completion of well development. The presence and thickness of free hydrocarbon product was determined using an oil/water interface probe. Based on this assessment, no free hydrocarbon product was detected. However, a slight sheen and discernable odor was observed during well development and sampling in monitoring wells ST05-MW2, MW5, MW6, MW8, and MW9 (see Figure 7-9).

7.5.3.5 Tidal Influence Assessment. Tidal monitoring was conducted at Site ST05 between 24 July and 26 July 1994 to evaluate tidal influences on the near-beach unconfined groundwater system during the Kotzebue LRRS 1994 Remedial Investigation. Tidal monitoring was conducted in selected monitoring wells (i.e., ST05-MW4, MW5, and MW6) during a period of high tidal fluctuation to increase the potential for measurable communication between the near-beach aquifer and Kotzebue Sound (see Section 4.4.6, Tidal Influence Assessment). Results of tidal monitoring indicate that tidal fluctuation in Kotzebue Sound clearly impacts the near-beach aquifer in the vicinity of Kotzebue LRRS. However, based upon the limited vertical extent of the water table aquifer and the observed tidal fluctuation in the monitoring wells it is unlikely that the tidal cycles have a significant effect on groundwater migration to the Sound. Observed changes in groundwater geochemistry at Site ST05 indicate that seawater is mixing with shallow groundwater along the upper beach face at Kotzebue LRRS.

7.5.3.6 Natural Attenuation Assessment. During the 1994 RI, data were obtained from soil and groundwater at Site ST05 to specifically address whether natural attenuation is active, and to what extent biodegradation may be responsible for the reduction of petroleum hydrocarbon concentrations at Kotzebue LRRS. Geochemical parameters were measured in groundwater both upgradient and downgradient of the known source area to document the relationship between aqueous geochemistry and contaminant chemistry, allowing an evaluation of the effect of natural biodegradation on groundwater associated with the ST05-Beach Tanks site. Additionally, soil contamination was evaluated using carbon chain ratios (straight-chain/branched chain) to determine the difference in composition between fresh and degraded diesel fuel at known source areas (see Section 4.6.6, Natural Attenuation Assessment Results). Results indicate that natural attenuation is occurring, and that biodegradation may be a significant process in both soil and groundwater associated with the beach area at Kotzebue LRRS.

7.5.4 Remaining Site Concerns

Table 7-5 provides a summary of state and federal regulatory criteria (ARARs) and risk-based criteria exceeded in soil and groundwater at Site ST05. State and federal ARARs established to guide the 1994 RI are at least as stringent as those criteria developed during previous IRP investigations at Kotzebue LRRS (see Section 4.2, Applicable or Relevant and Appropriate Requirements).

7.5.4.1 Soil. During the 1994 RI, a total of 24 shallow subsoil samples and three surface soil samples were collected from Site ST05 (see Table 7-4). Fourteen of the 24 subsoil samples contained diesel range

TABLE 7-5. SUMMARY OF IRP CLEANUP CRITERIA EXCEEDANCE AT SITE ST05-BEACH TANKS, KOTZEBUE LRRS, ALASKA

ARAR[a] Exceedance				Risk Based Exceedance[h]					
				Human Health	Ecological				
Media	Chemical of Concern	Sample Concentration	ARAR Criteria		Media	Pathway	Chemical of Concern	Sample Concentration	Ecological Criteria
1988 Stage 1 RI/FS									
Soil	TPH	5,300 mg/kg	1,000 mg/kg[b]	Not Evaluated	Not Evaluated				
1989-1990 Stage 2 RI/FS									
Soil	TPH	21,000 mg/kg	1,000 mg/kg[b]	Not Evaluated	Not Evaluated				
Groundwater	TPH	8,700 mg/L	NA[c]	Not Evaluated	Not Evaluated				
1994 Remedial Investigation									
Soil	Diesel Range Organics	18,000 mg/kg	1,000 mg/kg[d]	No unacceptable risks were estimated	Soil	Dietary	2-methyl-naphthalene	55 mg/kg	6.6 mg/kg
							Total xylene	23 mg/kg	2.6 mg/kg
Groundwater	Total PAHs	505 μg/L[e]	15 μg/L[f]	No unacceptable risks were estimated	No unacceptable risks were estimated				
	Total BETX	562 μg/L[g]	10 μg/L[f]						
	Diesel Range Organics	34 mg/L	0.015 mg/L[f]						
Sea Water	None	--	--	No unacceptable risks were estimated	No unacceptable risks were estimated				

[a] Applicable or relevant and appropriate requirements.

[b] 1988 Stage 1 RI/FS recommended cleanup levels (USAF 1990a).

[c] NA = Not available; no groundwater criteria was identified during the Stage 2 RI/FS (USAF 1990b).

[d] Alaska Department of Environmental Conservation; Petroleum hydrocarbon target level of 1,000 mg/kg for soils at Kotzebue LRRS.

[e] The reported concentration equals the sum of the maximum semivolatile compounds concentrations detected in groundwater.

[f] Alaska Department of Environmental Conservation; Water Quality Standards Regulations (18 AAC 70; January 1995).

[g] The reported concentration equals the sum of the maximum BETX compounds concentrations detected in groundwater.

[h] Ecological and human health risk-based criteria established using 1994 Remedial Investigation results (USAF 1995b).

organics concentrations (up to a maximum of 18,000 mg/kg in Sample ST05-SB24) above the 1,000 mg/kg ADEC soil target level (see Figure 7-9). Sample ST05-SB24 was selected to evaluate residual range organics and assess other potential source(s) of petroleum hydrocarbon contamination (e.g., waste oils). Residual range organics results revealed a concentration of 36 mg/kg. Results of the natural attenuation assessment indicate that natural attenuation is actively occurring in soil at Kotzebue LRRS, and that biodegradation may be a significant process that will act to reduce remaining concentrations of DROs in site soil (see Section 4.6.6, Natural Attenuation Assessment Results). No detections of VOCs, SVOCs, or pesticides and PCBs in soil exceed applicable ARARs criteria established for Kotzebue LRRS (see Section 4.2, Applicable or Relevant and Appropriate Requirements). In support of the 1994 remedial investigation, a baseline risk assessment was conducted (USAF 1995b). No unacceptable human health risks were estimated for soil at Site ST05. The baseline risk assessment indicates a potential ecological risk to ground squirrels for the dietary pathway based on the detection of xylene (HQ = 2.73) and 2-methylnaphthalene (HQ = 2.42) in soil. Xylene detected in Subsoil Sample ST05-SB14 at 23 mg/kg exceeded the ecological threshold concentration of 2.6 mg/kg. 2-Methylnaphthalene detected in Sample ST05-SB16 at 55 mg/kg and in Sample ST05-SB17 at 36 mg/kg exceed an ecological threshold concentration of 6.6 mg/kg. All soil samples exceeding ecological threshold criteria for dietary pathway are located along the beach front, west of the beach access road. Ground squirrels are not expected to frequent these locations as they tend to favor the back-beach areas associated with the tundra hill.

7.5.4.2 ***Groundwater.*** During the 1994 RI, nine groundwater samples were collected from monitoring wells installed at Site ST05 to estimate the extent of groundwater contamination, provide representative and reproducible groundwater samples for aquifer characterization, and to evaluate the groundwater potentiometric surface (see Figure 7-9). Diesel range organics were detected in seven of the nine groundwater samples collected at Site ST05. The maximum diesel range organics detection in groundwater at Site ST05 was 34 mg/L in monitoring well ST05-MW9. BETX compounds were detected in five of nine groundwater samples collected. Semivolatile compounds (e.g., 2-methylnaphthalene) were detected in six of the nine groundwater samples collected at Site ST05. Shallow groundwater contamination at Site ST05 is restricted to an approximate 1,050 foot by 200 foot area. Figures 7-10 and 7-11 show groundwater contaminant distribution at Site ST05. Figures 7-10 and 7-11 include wells installed at Site SS02 to show lateral extent of groundwater contamination to the north.

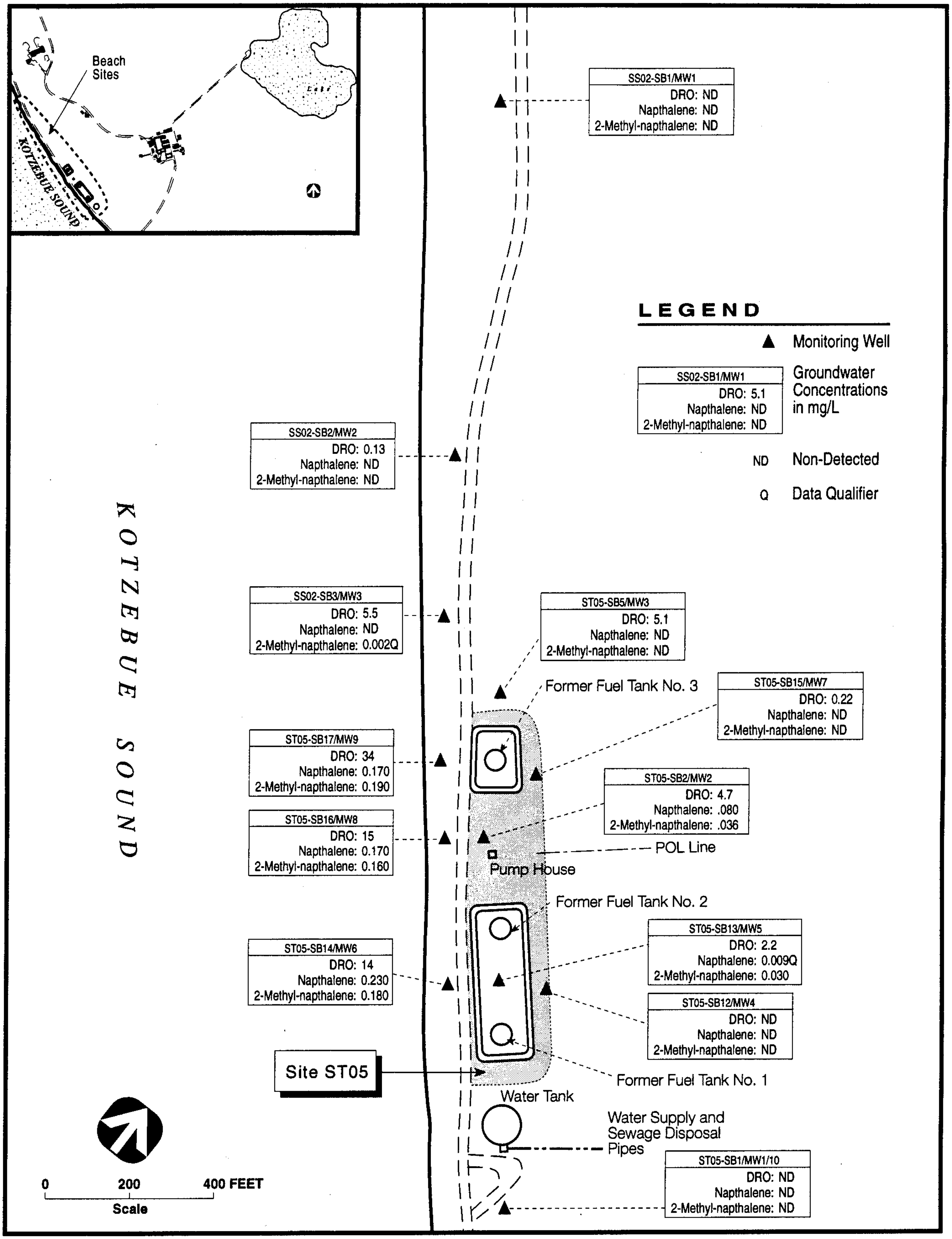


Figure 7-10. Groundwater Contaminant Distribution Map for DRO's, Napthalene, and 2-Methyl-napthalene Concentrations at Beach Sites SS02 and ST05, 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

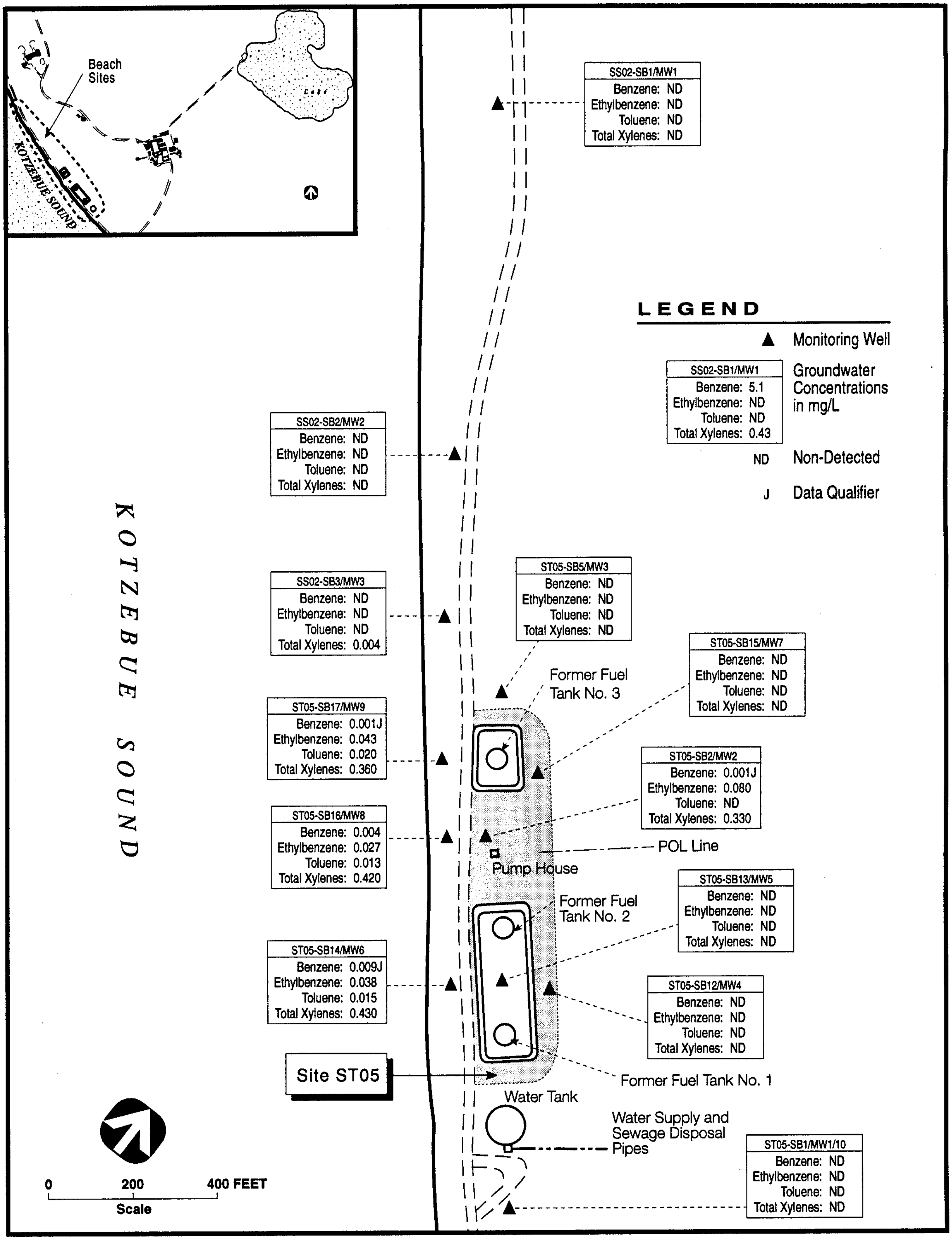


Figure 7-11. Groundwater Contaminant Distribution Map for Benzene, Ethylbenzene, Toluene, and Total Xylenes (BETX) Concentrations at Beach Sites SS02 and ST05, 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

Previous site characterization data for Site ST05 obtained in 1989 yielded a maximum petroleum hydrocarbon concentration in groundwater of 8,700 mg/L (see Section 3.3, Stage 2 RI/FS; Table 3-6). The decrease in petroleum hydrocarbon concentration observed between 1989 and 1994 may be the result of natural degradation processes occurring in the shallow near-beach aquifer. However, the most likely factor responsible for the decrease in groundwater petroleum hydrocarbon concentration is the variance between groundwater sampling methods employed between investigations. During the 1989 investigation, groundwater samples were collected directly from excavation pits, where petroleum contaminated soils were likely mixed with formation groundwater, yielding artificially high petroleum hydrocarbon contamination nonrepresentative of true aquifer conditions. However, during the 1994 characterization of the near-beach aquifer, monitoring wells were installed, developed, and sampled to ensure the collection of representative and reproducible groundwater data to allow accurate characterization of the shallow near-beach aquifer. Additionally, groundwater samples collected during the 1989 investigation were analyzed for petroleum hydrocarbons by Method E 418.1. The results from Method E418.1 analysis are questionable because the extraction technique associated with this method does not provide for distinction between organic contaminants and naturally occurring hydrocarbons. During the 1994 RI, all groundwater samples were analyzed specifically for diesel range organics using Alaska Method AK 102 (see Table 7-4).

Due to the relatively shallow nature of the near-beach aquifer system at Kotzebue LRRS and its proximity to Kotzebue Sound, ADEC considers the beach area at Kotzebue LRRS (including the shallow near-beach groundwater system) regulated under Water Quality Standards Regulation (see Section 4.2, Applicable or Relevant and Appropriate Requirements). The concentration of DROs in monitoring wells at Site ST05 all exceed the 0.015 mg/L ADEC Water Quality Standard for petroleum hydrocarbons in surface water (ADEC 1995). However, any detection of DROs in groundwater at Kotzebue LRRS will exceed ADEC Water Quality Criteria for petroleum hydrocarbons, as current laboratory analytical methods cannot obtain method detection limits below ADEC criteria. The concentrations of total BETX and total PAHs measured in groundwater exceed ADEC water quality criteria at Site ST05 (see Table 7-5). No unacceptable ecological or human health risks were estimated for the groundwater pathway at Site ST05 (USAF 1995b). Results of the natural attenuation assessment indicate that natural attenuation is actively occurring in affected groundwater at Site ST05, and that biodegradation may be a significant process that will act to reduce remaining concentrations of DROs and BETX compounds in site groundwater (see Section 4.6.6, Natural Attenuation Assessment Results).

7.5.4.3 Seawater. Three seawater samples were collected from Kotzebue Sound adjacent to Site ST05 during the 1994 RI (see Table 7-4). The samples were collected below the water surface from nearshore locations spaced along the beach adjacent to the former fuel storage tanks (see Figure 7-9). Analytical results from these samples indicated no detection of VOCs, SVOCs, or DROs in seawater adjacent to the source area at Site ST05. No unacceptable ecological or human health risks were estimated for Kotzebue Sound based on groundwater contaminant migration assumptions (USAF 1995b).

7.5.5 Site Recommendations

Based on past IRP activities conducted at Site ST05, the remaining levels of contaminants detected, and a review of associated ARARs and baseline risk assessment, limited remedial action is recommended at Site ST05, including natural attenuation and long-term groundwater monitoring to evaluate potential contaminant migration to Kotzebue Sound and measure the effectiveness and rate of natural attenuation. The natural attenuation and long-term monitoring alternative represents a non-invasive, non-destructive alternative to material removal actions or other approaches that would negatively impact the beach area and local ecosystem at Kotzebue LRRS. Groundwater monitoring is recommended on a biannual basis and should include sampling all available site monitoring wells for volatile organics (e.g., BETX compounds), semivolatile organics, and diesel range organic compounds. Analytical results from biannual groundwater monitoring events should be evaluated for compliance with ARARs and effectiveness of natural attenuation to determine if subsequent groundwater monitoring at Site ST05 is warranted.

7.6 SITE SS06-SPILL/LEAK NO. 1

7.6.1 Summary of Site Status

Site SS06-Spill/Leak No. 1 is the reported location of a diesel fuel leak which occurred in a fuel pipeline in the mid-1970s. Absorbent materials were reportedly used to cleanup the fuel that remained on the surface of the ground. No evidence of contamination was identified during site reconnaissance conducted at Site SS06 in 1987. The USAF issued a Final No Further Action Decision Document for Site SS06 in July 1991. ADEC concurred with the No Further Action alternative for this site in correspondence to the USAF dated December 1991. The USAF and ADEC consider Site SS06 closed.

7.6.2 Site Description

Site SS06 is located near the northern wing of the Composite Facility (Figure 7-12). The site is the reported location of a diesel fuel leak which occurred in a fuel pipeline in the mid-1970s (USAF 1985).

7.6.3 IRP Investigation Summary

Site SS06 was identified in a 1985 USAF Phase I Report as a diesel fuel spill which occurred when a coupling near the officer's wing of Building 103 failed, resulting in the release of an unknown volume of diesel fuel to the ground (USAF 1985). Absorbent materials were reportedly used to cleanup the fuel that remained on the ground surface. In 1987, a survey was conducted at Site SS06 and found no evidence of contamination at the site. Site SS06 was excluded from the 1988 Stage 1 RI/FS investigation based on the 1987 site reconnaissance findings.

7.6.4 Remaining Site Concerns

There are no remaining environmental concerns associated with Site SS06.

7.6.5 Site Recommendations

In July 1991, the USAF issued a Final No Further Action Decision Document for Site SS06 (USAF 1991). ADEC concurred with the No Further Action alternative for this site in correspondence to the USAF dated November 1991 (ADEC 1991a). The USAF and ADEC consider Site SS06 closed.

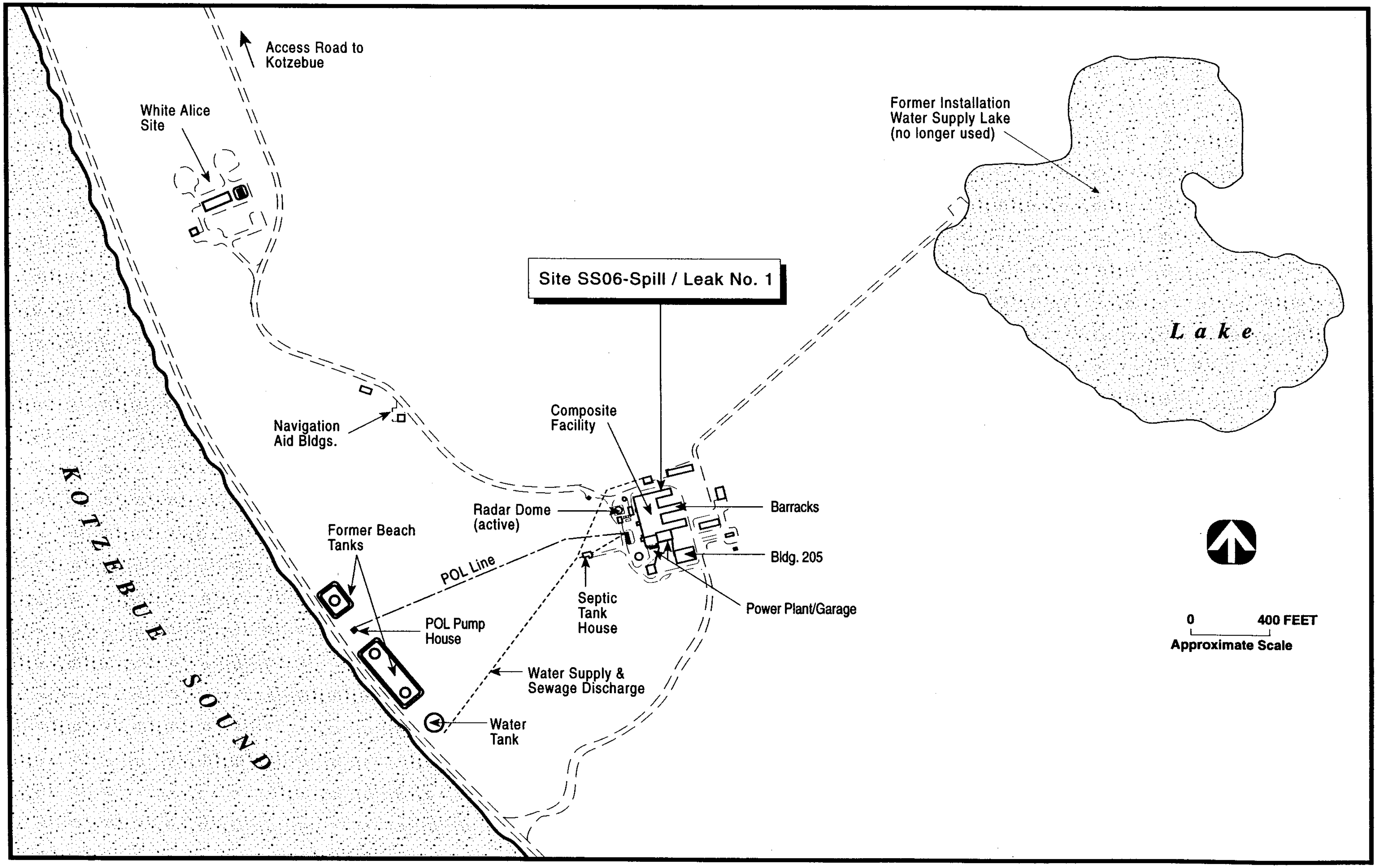


Figure 7-12. Location of Site SS06-Spill / Leak No. 1, Kotzebue LRRS, Alaska.

7.7 SITE SS07-LAKE

7.7.1 Summary of Site Status

Site SS07-Lake is the location of a lake formerly used as the water supply for the Kotzebue LRRS. Pesticides and PCBs detected in a single sediment sample (e.g., Aroclor 1260 at 3.4 mg/kg) during the 1988 Stage 1 RI/FS was the primary environmental concern at the site. The USAF recommended no further action at Site SS07 based on the lack of surface water contamination, relatively low concentrations of pesticides and PCB (Aroclor 1260) in sediments, and the estimated slow rate of suprapermafrost (active zone) water migration from the site. However, ADEC requested the USAF to evaluate the source and extent of pesticides and PCBs detected in lake sediments during the 1988 Stage 1 RI/FS (ADEC 1991a). Based on the 1994 RI results for Site SS07, including the lack of contamination detected in lake sediments and a review of associated ARARs and baseline risk assessment criteria, no further action is recommended for Site SS07-Lake. A Final No Further Action Decision Document for Site SS07 will be submitted.

7.7.2 Site Description

Site SS07 is located approximately 0.5 miles northeast of the Composite Facility, at an approximate elevation of 37 feet above sea level (Figure 7-13). The lake has been described as a receptor of spring breakup water and served as the installation's drinking water supply until 1985 (USAF 1990b). The lake's shoreline measures approximately 1,000 feet by 600 feet; however, during the mid and late summer months, the lake's area and volume are significantly reduced. The lake was observed to be partitioned into two distinct surface water bodies during the 1994 RI conducted in late June and July (Figure 7-14). The total depth of the lake has not been determined; however, aerial photographs indicate that the lake is relatively shallow (i.e., less than 20 feet deep). The lake seasonally (i.e., during breakup) drains to the north toward June Creek, located approximately 1 mile to the north of the Composite Facility.

7.7.3 IRP Investigation Summary

Table 7-6 provides a summary of IRP activities conducted at Site SS07. During the 1988 Stage 1 RI/FS, the former water supply lake was characterized by collecting one sediment and one surface water sample near the facility's surface water intake (see Table 7-6). A summary of maximum detected concentrations is provided in Section 3.2, Stage 1 RI/FS; Table 3-3. No further action was recommended at Site SS07

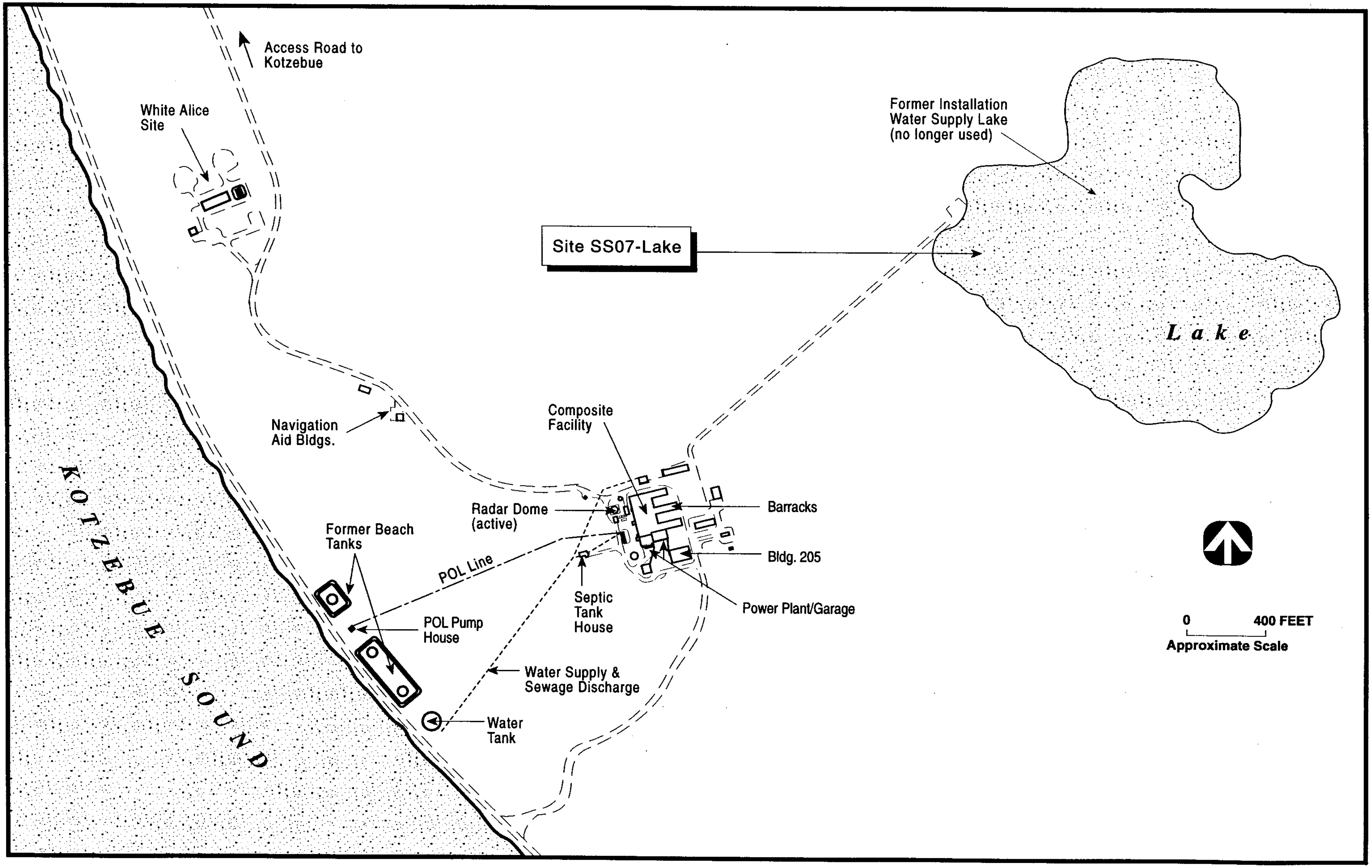
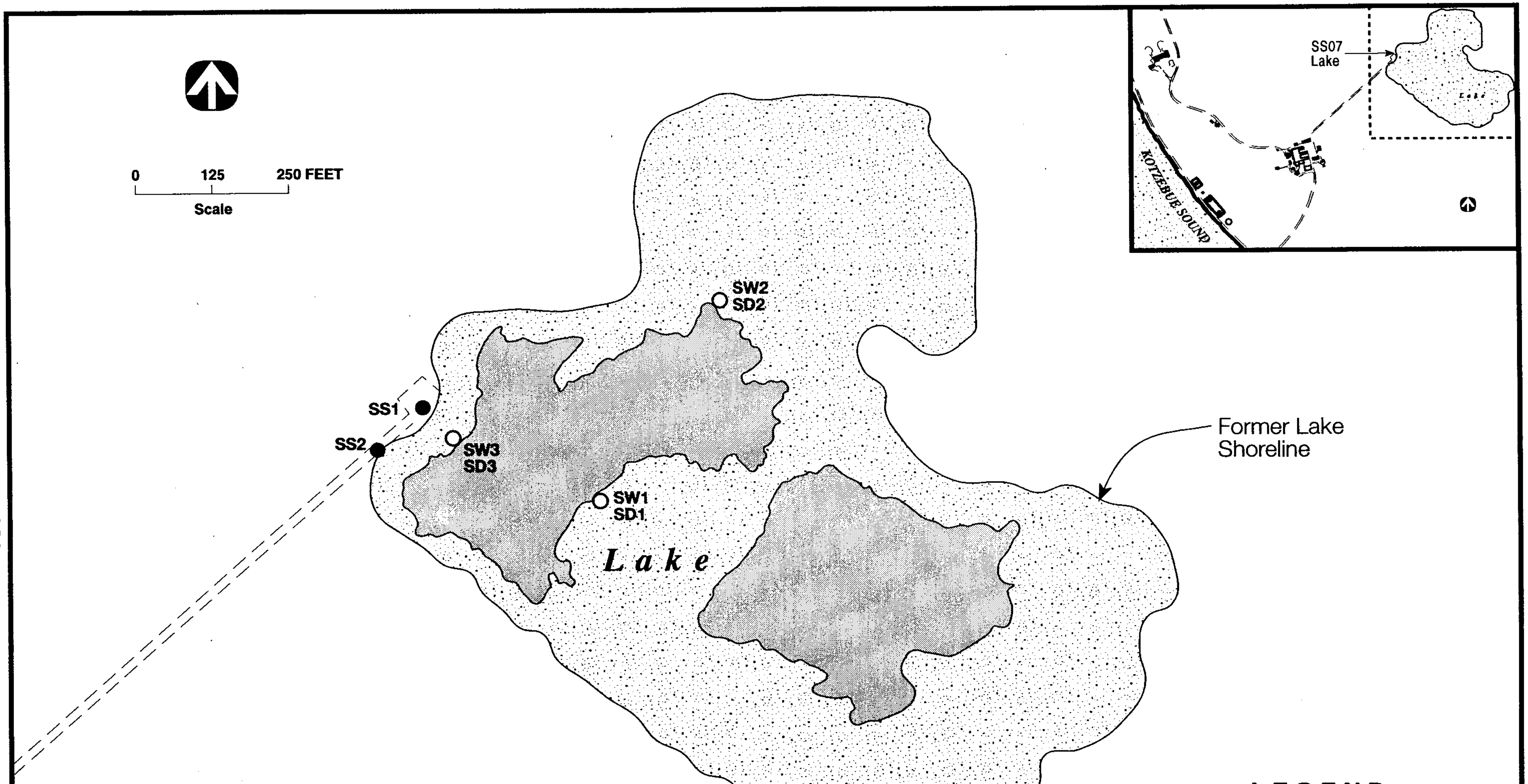


Figure 7-13. Location of Site SS07-Lake, Kotzebue LRRS, Alaska.



DIESEL RANGE ORGANICS
(Method AK102) SUMMARY TABLE

Sample	Depth (ft)	DRO [mg/kg]
SS07-SD1	–	60
SS07-SD2	–	440
SS07-SD3	–	160
SS07-SW1	–	ND
SS07-SW2	–	ND
SS07-SW3	–	ND

Figure 7-14. Location of Sample Stations at Site SS07-Lake, 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

TABLE 7-6. SUMMARY OF IRP ACTIVITIES CONDUCTED AT SITE SS07-LAKE, KOTZEBUE LRRS, ALASKA

Field Sampling	Analyses Performed	Field Activities
1988 Stage 1 RI/FS		
1 Sediment Sample	Petroleum Hydrocarbons (EPA Method E 418.1) Volatile Organic Compounds (EPA Method SW 8240) Organochlorine Pesticides and PCBs (EPA Method SW 8080)	■ Field Sampling
1 Surface Water Sample	Petroleum Hydrocarbons (Method 418.1) Organochlorine Pesticides and PCBs (EPA Method SW 8080) Purgeable Halocarbons (EPA Method SW 8010) Purgeable Aromatics (EPA Method SW 8020) Semivolatile Organic Compounds (EPA Method SW 8270) ICP Screen (23 metals) (EPA Method SW 6010) Arsenic (total and dissolved) (EPA Method SW 7060) Lead (total and dissolved) (EPA Method SW 7421) Mercury (total and dissolved) (EPA Method SW 7740) Selenium (total and dissolved) (EPA Method SW 7740)	
1994 Remedial Investigation		
2 Surface Soil Samples	Pesticides and PCBs (EPA Method SW 8081)	■ Field Sampling ■ All sample locations were surveyed
3 Sediment Samples	(3) Diesel Range Organics (Method AK102) (1) Volatile Organic Compounds (EPA Method SW 8260) (3) Semivolatile Organic Compounds (EPA Method SW 8270) (3) Pesticides and PCBs (EPA Method SW 8081) (2) Total Metals (EPA Method 6010 series; 7000 series for lead and mercury)	
3 Surface Water Samples	(3) Diesel Range Organics (Method AK102) (1) Volatile Organic Compounds (EPA Method SW 8260) (3) Semivolatile Organic Compounds (EPA Method SW 8270) (3) Pesticides and PCBs (EPA Method SW 8081) (1) Total/Dissolved Metals (EPA Method 6010 series; 7000 series for lead and mercury)	

based on the lack of surface water contamination, relatively low concentrations of pesticides and PCB (Aroclor 1260) in sediments, and the estimated slow rate of suprapermafrost (active zone) water migration from the site (USAF 1991a).

Due to the detection of PCBs (Aroclor 1260 at 3.4 mg/kg) and pesticides (4,4'-DDT at 2.6 mg/kg) in a single sediment sample, ADEC did not concur with the USAF No Further Action alternative for Site SS07. In correspondence to the USAF dated November 1991, ADEC requested the USAF to establish potential PCB and pesticide source areas which may be causing contaminants to enter the former water supply lake (ADEC 1991a). ADEC also requested additional characterization of lake sediments to evaluate the extent of potential contamination.

During the 1994 RI, Site SS07 was characterized to verify the presence of previously identified contamination, evaluate the nature and extent of potential contamination, and evaluate potential contaminant source areas. Site characterization included the collection of two surface soil samples near the former water supply intake, and three sediment and surface water samples at locations around the lake (see Table 7-6). Figure 7-14 provides the 1994 RI sample station locations at Site SS07. A summary of maximum detected concentrations identified at Site SS07 during the 1994 is provided in Section 4.5, Summary of Analytical Results; Tables 4-12 through 4-21. All sample analytical results for the 1994 RI are provided in Appendix L.

7.7.4 Remaining Site Concerns

State and federal ARARs established to guide the 1994 RI are discussed in Section 4.2, Applicable or Relevant and Appropriate Requirements. The ARARs used to guide the 1994 RI are at least as stringent as those criteria developed during previous IRP investigations at Kotzebue LRRS.

7.7.4.1 Soil. During the 1994 RI, two surface soil samples were collected from the lake access road near the water supply intake to evaluate the potential of road oiling as the source of previously identified PCBs in lake sediment (see Figure 7-14). No PCBs were detected in surface soil samples collected at Site SS07 (see Appendix L).

7.7.4.2 Sediment. Three sediment sample were collected from Site SS07 during the 1994 RI (see Table 7-6). One sample was collected at or near a previously investigated location to confirm the

presence of previously detected contamination (e.g., PCBs). Two additional samples were collected to estimate the potential extent of contamination (see Figure 7-14). No PCBs were detected in any of the sediment samples collected. Sediment Sample SS07-SD2 was selected to evaluate residual range organics in lake sediment. The original AK102 extract was reanalyzed (within specified holding times) using an extended AK102 method to quantify residual range organics between C28 through C40. Results indicate RROs at 2,400 mg/kg, as compared to DROs at 400 mg/kg in the same sample. In support of the 1994 remedial investigation, a baseline risk assessment was conducted (USAF 1995b). No ARARs or ecological risk based criteria were exceeded based on the sediment sample results for Site SS07 (see Section 4.5, Summary of Analytical Results; Tables 4-12 through 4-16). The baseline risk assessment indicates a potential risk to human health (i.e., $>10^{-6}$ risk) for soil/sediment ingestion (1.99E-6), based on the detection of arsenic in sediment sample SS07-SD1 at 10 mg/kg. Although detection of arsenic in sediment exceeds the health-based threshold concentration (i.e., 4.74 mg/kg) at Site SS07, the detection of arsenic is less than the arithmetic mean concentration measured in background samples (i.e., 27 mg/kg). No known sources of arsenic are identified for Site SS07 and the detection of arsenic in background locations indicate this element is naturally occurring. The average concentration of arsenic in natural soils is reportedly 5 mg/kg, but can range from 1 mg/kg to 50 mg/kg (EPA 1983).

*7.7.4.3 **Surface Water.*** Three surface water samples were collected from the former water supply lake at locations near those selected for sediment sampling (see Table 7-6). Surface water samples were collected prior to the collection of sediment samples to avoid the incorporation of disturbed sediment in water samples (see Figure 7-14). No VOCs, SVOCs, or DROs were detected in surface water samples collected during the 1994 RI (see Section 4.5, Summary of Analytical Results; Tables 4-12 through 4-16). The only pesticide compound detected in surface water was heptachlor epoxide, found in sample SS07-SW1 at 0.12 μg/L. This concentration exceeds the federal water quality criteria of 0.0010 μg/L for heptachlor epoxide established for the State of Alaska, based on the protection of human health from the consumption of contaminated water, fish, and/or shellfish (EPA 1992). No ecological risk based criteria were exceeded based on surface water sample results for Site SS07. The baseline risk assessment indicates a potential risk to human health (i.e., $>10^{-6}$ risk) for dermal contact with surface water (i.e., 1.1E-6) based on the detection of heptachlor epoxide at 0.12 μg/L in Sample SS07-SW1.

7.7.5 Site Recommendations

ADEC requested the USAF to evaluate the source and extent of pesticides and PCBs detected in lake sediments during the 1988 Stage 1 RI/FS (ADEC 1991a). No documented use of pesticides has been identified at Kotzebue LRRS; however, pesticides may have been used to control insects. Pesticides were ubiquitously detected at relatively low concentrations during the 1994 RI, including all background soil sample locations (see Section 4.5, Summary of Analytical Results). There is no current pesticide application and no source identified for any potential past pesticides use; therefore, heptachlor epoxide levels detected in the lake will decrease gradually with time. Since no one drinks lake water, or swims in it, and the ecological risk assessment showed no significant risk, no remedial action is recommended.

Previous detection of PCBs at Kotzebue LRRS was limited to two locations at the White Alice Site (USAF 1990b). It is not likely that PCB contamination has migrated from the White Alice Site to the former water supply lake based on the relatively low mobility of PCBs in the environment, low permeability and high organic carbon content of native soils, and the relatively poor drainage associated with the site (see Section 5.0, Site Conceptual Model). Past waste practices at Kotzebue LRRS include the use of waste oils for dust control along installation access roads. Previous site characterization of road oiling (Site SD03) activities at the installation revealed no detection of PCBs. However, a road exists between the main facility and the former water supply intake at the lake; therefore, this road was considered a suspected (potential) source for the PCBs previously identified in lake sediments. During the 1994 RI, two surface soil samples were collected from the lake access road near the water supply intake to evaluate the potential of road oiling as the source of previously identified lake sediment contamination (see Figure 7-14). No PCBs were detected in surface soil samples collected at Site SS07.

Based on the 1994 RI results for Site SS07, including the lack of contamination detected in lake sediments and a review of associated ARARs and baseline risk assessment criteria, no further action is recommended for Site SS07-Lake. The USAF will prepare closure documents for this site, recommending no further action.

7.8 SITE SS08-BARRACKS PAD

7.8.1 Summary of Site Status

Site SS08-Barracks Pad was originally described as a 25-foot by 40-foot gravel pad which was reportedly used to store facility chemicals such as solvents, rust inhibitors, and various fluorocarbons; however, during the 1994 RI, the site was expanded to include the entire area between and surrounding the western wings of the Composite Facility where small day tanks are located and where visual signs of surface soil staining were evident. Petroleum hydrocarbons in gravel fill material (up to 33,000 mg/kg) is the primary environmental concern identified at the site. It is recommended that contaminated fill materials which currently exceed the ADEC soil target level of 1,000 mg/kg be excavated and removed from the site. Onsite treatment of contaminated fill materials is recommended to reduce petroleum hydrocarbon concentrations to acceptable levels for onsite disposal of treated soil.

7.8.2 Site Description

Site SS08 is located between the west wings of the Composite Facility (Figure 7-15). The site is described as a 25-foot by 40-foot gravel pad which was reportedly used to store facility chemicals, such as solvents, rust inhibitors, and various fluorocarbons (USAF 1990a). Small above-ground diesel fuel tanks located adjacent to the Barracks Pad are reportedly a potential source of diesel fuel contamination.

The average depth of fill materials at Site SS08 is approximately 3 feet. Frozen ground was encountered during the investigation at approximately 2 to 3 feet below ground surface. Suprapermafrost (active zone) water was detected in shallow borings at an approximate 1 foot depth (USAF 1995a). The ground surface at Site SS08 is relatively flat and is characterized as having poor drainage, with an assumed direction of flow toward the east to southeast (see Figure 7-15).

7.8.3 IRP Investigation Summary

Table 7-7 provides a summary of IRP activities conducted at Site SS08. During the 1988 Stage 1 RI/FS, five shallow hand auger borings were installed and three discrete soil samples were collected for analysis (see Table 7-7). A summary of maximum detected concentrations is provided in Section 3.2, Stage 1 RI/FS; Table 3-3. The USAF recommended no further action for Site SS08, as no cleanup criteria were exceeded during the Stage 1 RI/FS. However, ADEC did not concur with the no further action alternative for this site, stating that petroleum hydrocarbons were detected in soil at 5,960 mg/kg and that

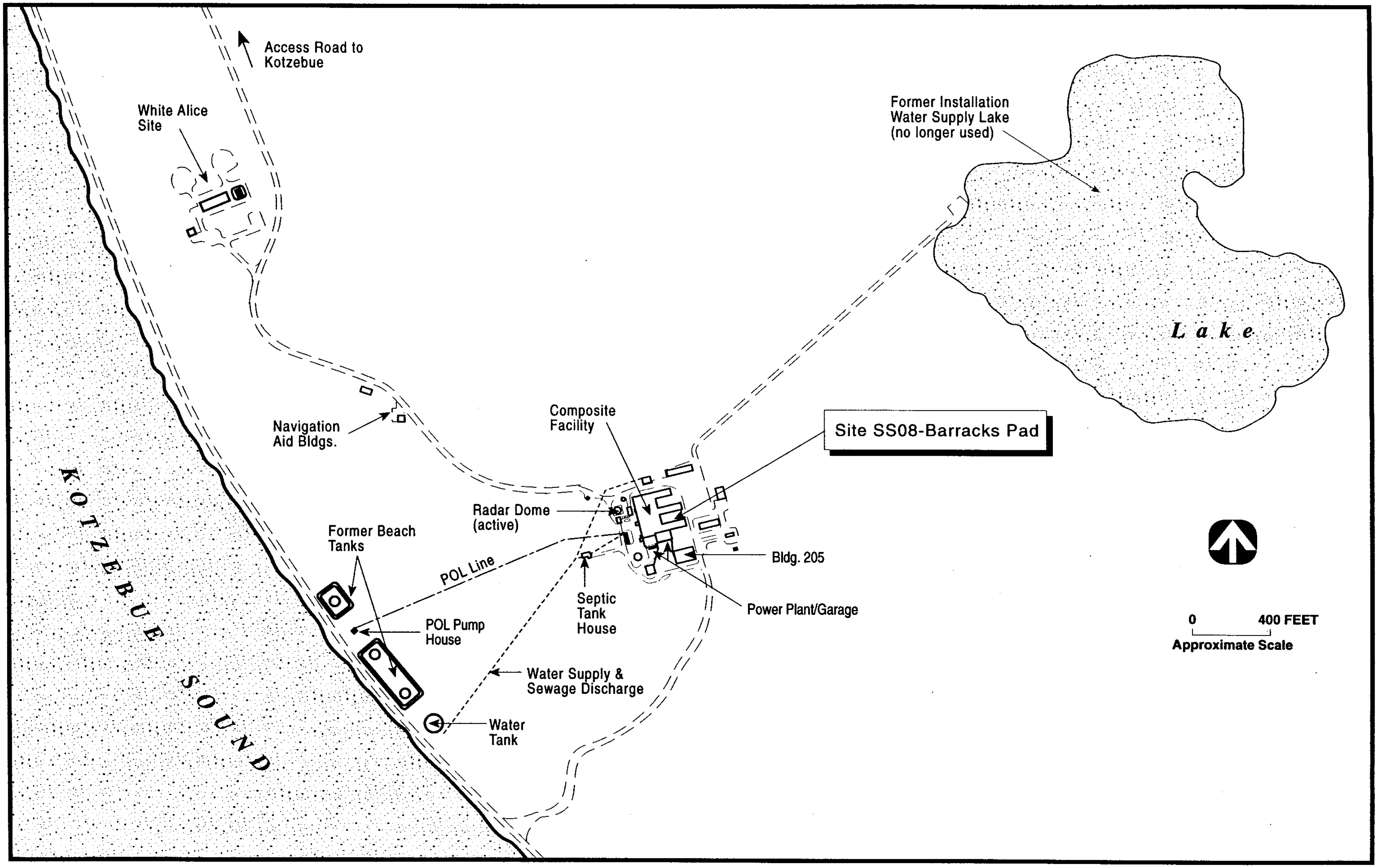


Figure 7-15. Location of Site SS08-Barracks Pad, Kotzebue LRRS, Alaska.

TABLE 7-7. SUMMARY OF IRP ACTIVITIES CONDUCTED AT SITE SS08-BARRACKS PAD, KOTZEBUE LRRS, ALASKA

Field Sampling	Analyses Performed	Field Activities
1988 Stage 1 RI/FS		
3 Soil Samples	Petroleum hydrocarbons (EPA Method E418.1) Volatile Organic Compounds (EPA Method SW8240) Organochlorine Pesticides and PCBs (EPA Method SW8080)	■ Five hand auger borings were installed ■ All sample locations were surveyed
1994 Remedial Investigation		
4 Soil Samples	(4) Diesel Range Organics (Method AK102) (1) Residual Range Organics (Method AK102-Extended) (4) Volatile Organic Compounds (Method EPA 8260) (4) Semivolatile Organic Compounds (Method EPA SW8270) (4) Pesticides and PCBs (Method EPA SW8081) (2) Metals (EPA Method 6010 series)	■ All sample locations were surveyed

the Stage 1 RI/FS recommended cleanup level for petroleum hydrocarbons in soil of 10,000 mg/kg was not acceptable. ADEC recommended the establishment of approved cleanup levels for petroleum contaminated soil at Kotzebue LRRS, and additional sampling to establish extent of diesel fuel contamination at the site (ADEC 1991a).

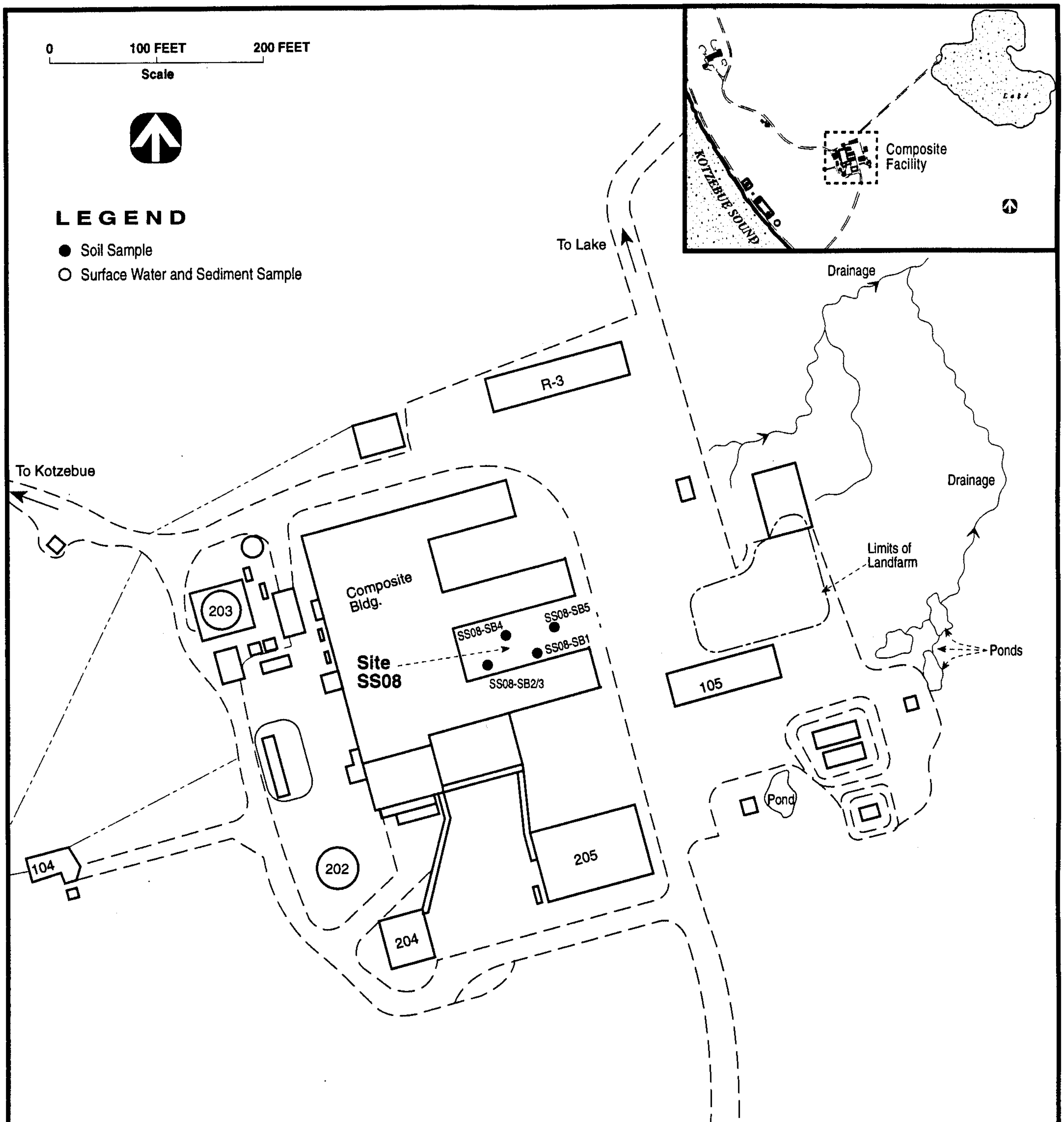
In preparation for the 1994 RI, the USAF and ADEC discussed project cleanup goals and state regulation requirements. ADEC indicated that sites at Kotzebue LRRS are considered under regulation by the Water Quality Standards Regulation (18 AAC 70). ADEC indicated that the use of Interim Guidance for Non-UST Contaminated Soil Cleanup Levels, dated July 17, 1991, is not applicable for developing soil cleanup levels due to the occurrence of and potential for petroleum hydrocarbon contamination in surface water and near-beach groundwater at the facility. However, ADEC established a soil target level for petroleum hydrocarbon (diesel range organics) contaminated soils at 1,000 mg/kg, to assist in the definition of the lateral and vertical extent of petroleum hydrocarbon contaminated soils associated with sites at Kotzebue LRRS (Noland, L., February 1994, personal communication).

During the 1994 RI, four shallow subsoil samples were collected to evaluate current site conditions and determine extent of potential contamination at Site SS08 (see Table 7-7). The four samples were collected within and adjacent to the 25-foot by 40-foot gravel pad located between the west wings (southern corridor) of the Composite Facility (Figure 7-16). A summary of maximum detected concentrations identified at Site SS08 during the 1994 RI is provided in Section 4.5, Summary of Analytical Results; Tables 4-12 through 4-16. All sample analytical results for the 1994 RI are provided in Appendix L.

7.8.4 Remaining Site Concerns

Table 7-8 provides a summary of state and federal regulatory criteria (ARARs) and risk-based criteria exceeded in soil at Site SS08. State and federal ARARs established to guide the 1994 RI are discussed in Section 4.2, Applicable or Relevant and Appropriate Requirements. The ARARs used to guide the 1994 RI are at least as stringent as those criteria developed during previous IRP investigations at Kotzebue LRRS.

During the 1994 RI, one of four soil samples was detected with diesel range organics concentrations exceeding the 1,000 mg/kg ADEC soil target level at Site SS08, including Samples SS08-SB1 at 33,000 mg/kg (see Figure 7-16). Sample SS08-SB1 was selected to evaluate residual range organics



DIESEL RANGE ORGANICS (Method AK102) SUMMARY TABLE		
Sample	Depth (ft)	DRO [mg/kg]
SS08-SB1	1.0	33,000
SS08-SB2/3	1.0	150
SS08-SB4	1.5	35
SS08-SB5	1.5	3.3

Figure 7-16. Location of Sample Stations at Site SS08-Barracks Pad, 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

TABLE 7-8. SUMMARY OF IRP CLEANUP CRITERIA EXCEEDANCE AT SITE SS08-BARRACKS PAD, KOTZEBUE LRRS, ALASKA

ARAR[a] Exceedance				Risk Based Exceedance[c]									
				Human Health					Ecological				
Media	Chemical of Concern	Sample Concentration	ARAR Criteria	Media	Pathway	Chemical of Concern	Sample Concentration	Health-Based Criteria	Media	Pathway	Chemical of Concern	Sample Concentration	Ecological Criteria
1988 Stage 1 RI/FS													
Soil	None	--	--	Not Evaluated					Not Evaluated				
1994 Remedial Investigation													
Soil	Diesel Range Organics	33,000 mg/kg	1,000 mg/kg[b]	Soil	Berry Ingestion	2-nitroaniline	8.7 mg/kg	0.28 mg/kg	Soil	Dietary	2-Methyl-naphthalene	59 mg/kg	6.6 mg/kg
					Soil Ingestion	Arsenic	10 mg/kg	4.47 mg/kg					
					Dust Inhalation	Arsenic	10 mg/kg	4.61 mg/kg					

[a] Applicable or relevant and appropriate requirements.

[b] Alaska Department of Environmental Conservation; Petroleum hydrocarbon target level of 1,000 mg/kg for soils at Kotzebue LRRS.

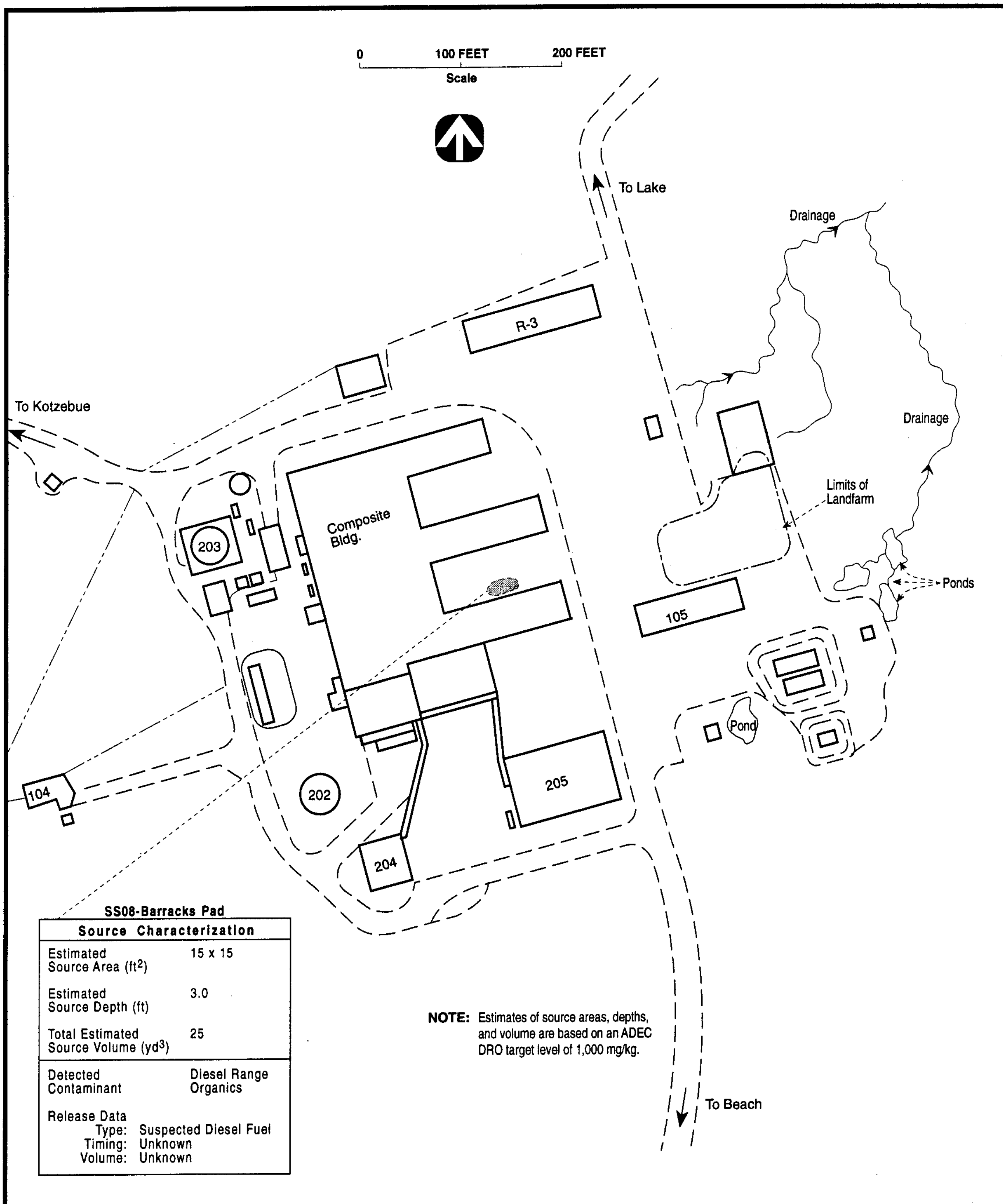
[c] Human health and ecological risk-based criteria established using 1994 Remedial Investigation results (USAF 1995b).

concentration and assess other potential source(s) of petroleum contamination (e.g., waste oils). The extraction from the original AK102 analysis was reanalyzed (within method-specific holding times) using an extended AK102 method to quantify petroleum hydrocarbons detected between C28 and C40. Results revealed a residual range organics concentration of 290 mg/kg. The suspected source of diesel range organics detected in site soil is from small day tanks located at the site.

In support of the 1994 remedial investigation, a baseline risk assessment was conducted. Baseline risk assessment results indicate a potential ecological risk (i.e., HQ > 1) associated with the dietary pathway for ground squirrels based on the detection of 2-methylnaphthalene in a single soil sample (SS08-SB1) at 59 mg/kg (i.e., HQ = 2.23). The health risk assessment indicated a potential risk to human health (i.e., $> 10^{-6}$ risk) for soil ingestion (1.99E-6) and soil (dust) inhalation (2.14E-6) pathways based on the detection of arsenic in soil samples SS08-SB1 and SB4 at 10 mg/kg and 7 mg/kg, respectively. Although site soil samples exceed health based threshold criteria for arsenic (i.e., 4.74 mg/kg for ingestion and 4.61 mg/kg for inhalation), their concentrations are less than the arithmetic mean concentration of arsenic measured in background soil samples (i.e., 27 mg/kg). No known sources of arsenic are identified for Site SS08 and the detection of arsenic in background locations indicate this element is naturally occurring. The average concentration of arsenic in natural soils is reportedly 5 mg/kg, but can range from 1 mg/kg to 50 mg/kg (EPA 1983). A potential non-carcinogen human health risk (i.e., HQ > 1) was also identified for berry ingestion (HQ = 4.22) at Site SS08 due to the detection of 2-nitroaniline at 8.7 mg/kg in Sample SS08-SB1. Since Site SS08 is a gravel pad located between the southern wings of the composite facility, no berry picking activities will occur at this location (see USAF 1995b).

7.8.5 Site Recommendations

Based on the concentrations of diesel range organics remaining in soil, remedial action is recommended at Site SS08 including the excavation and removal of contaminated fill materials which currently exceed the ADEC soil target level of 1,000 mg/kg. Onsite treatment of contaminated fill materials is recommended to reduce petroleum hydrocarbon concentrations to acceptable levels for onsite disposal of treated soil. The estimated 390 cubic yards of contaminated material at or above the 1,000 mg/kg ADEC soil target level are located in an area 15 feet by 15 feet, with a depth of 3 feet (Figure 7-17).



SS08-Barracks Pad

Source Characterization	
Estimated Source Area (ft^2)	15 x 15
Estimated Source Depth (ft)	3.0
Total Estimated Source Volume (yd^3)	25
Detected Contaminant	Diesel Range Organics
Release Data	
Type:	Suspected Diesel Fuel
Timing:	Unknown
Volume:	Unknown

NOTE: Estimates of source areas, depths, and volume are based on an ADEC DRO target level of 1,000 mg/kg.

Figure 7-17. DRO Contaminant Source Characterization at Site SS08-Barracks Pad, 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

7.9 SITE SS09-PCB SPILL

7.9.1 Summary of Site Status

Site SS09-PCB Spill is the reported location of a PCB spill which occurred at the White Alice Site on a portion of a gravel pad measuring 10 by 10 feet. PCB contamination (up to 32 mg/kg) in soils found during the 1988 Stage 1 RI/FS was the primary environmental concern at the site. Remedial action (excavation and removal) conducted in 1989 removed approximately 5.3 cubic yards of PCB-contaminated soil from the site. Based on the post remedial action confirmation samples, the USAF issued a Final No Further Action Decision Document for Site SS09 in July 1991. ADEC concurred with the No Further Action alternative for this site in correspondence to the USAF dated December 1991. The USAF and ADEC currently consider Site SS09 closed.

7.9.2 Site Description

Site SS09 is located at the White Alice Site, approximately 0.5 miles northwest of the Composite Facility (Figure 7-18). The site is the reported location of a PCB spill which covered an approximate 10 by 10 foot portion of a gravel pad overlying disturbed tundra. The site reportedly showed poor drainage which was variable in direction (USAF1990a). No permafrost or active zone water was encountered during investigation or remedial activities conducted at the site.

7.9.3 IRP Investigation Summary

Site SS09 was characterized during the 1988 Stage 1 RI/FS by collecting three surface soil samples for analysis, including petroleum hydrocarbons (Method 418.1 E) and organochlorine pesticides and PCBs (Method SW 8080). A summary of maximum detected concentrations is provided in Section 3.2, Stage 1 RI/FS; Table 3-3. All sample locations were surveyed for elevation and horizontal coordinates (USAF 1990a).

Due to the detection of PCBs in soil at a maximum concentration of 32 mg/kg , the USAF conducted remedial activities in 1989 involving the excavation and removal of PCB-contaminated soil at Site SS09. The excavation was advanced to an approximate 5-foot radius and 1.8-foot depth. An estimated 5.3 cubic yards of contaminated soil was excavated, placed in 55-gallon drums, and shipped to the Defense Reutilization and Marketing Office at Elmendorf AFB, Alaska. Nine confirmation soil samples were collected and composited from the excavation to measure the effectiveness of the remedial action (1990b).

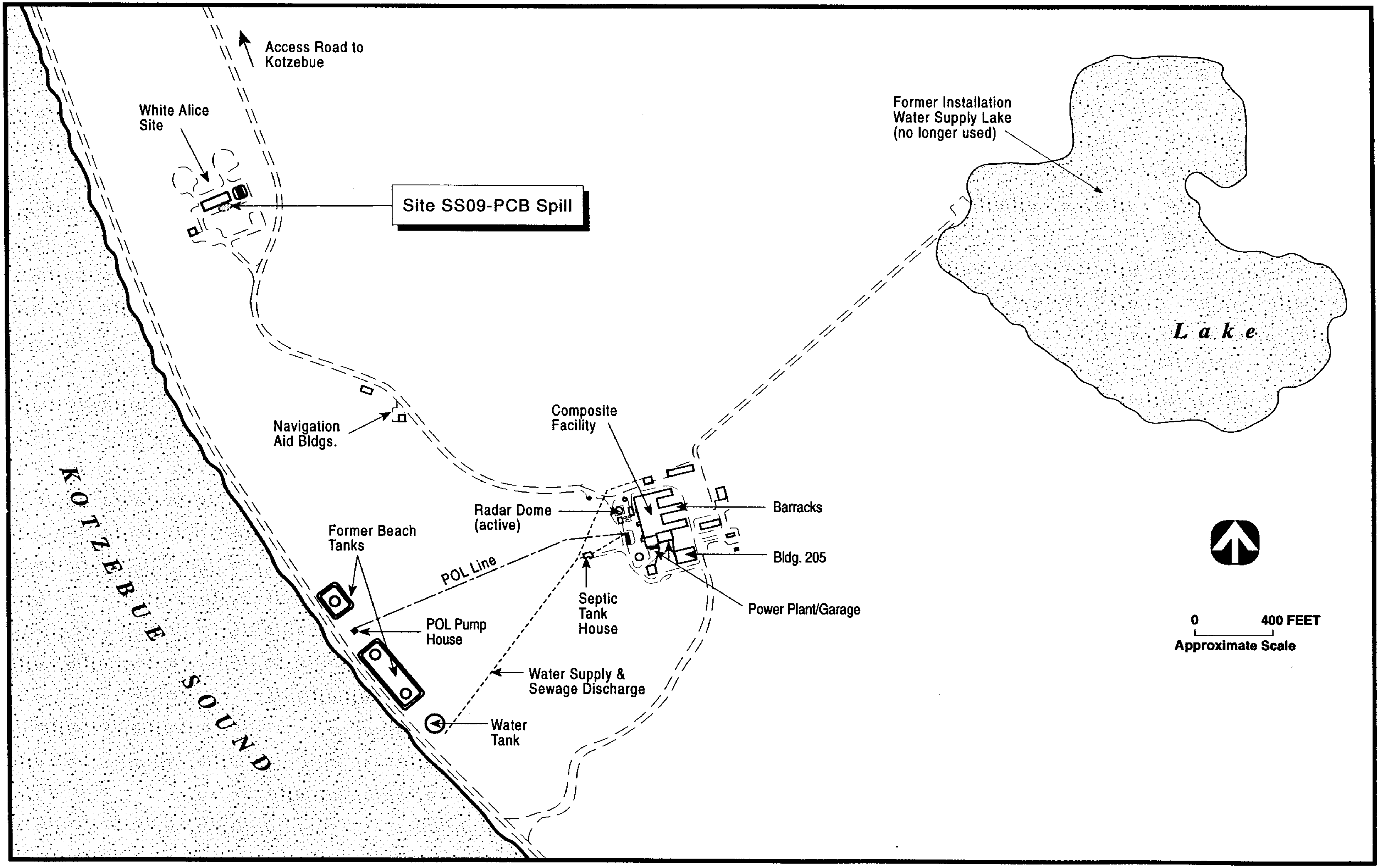


Figure 7-18. Location of Site SS09-PCB Spill, Kotzebue LRRS, Alaska.

7.9.4 Remaining Site Concerns

The target cleanup level for PCBs in site soils established for Kotzebue LRRS was 10 mg/kg (USAF 1990b). Soil samples collected to confirm the removal of PCBs in site soils revealed PCB concentrations in the base and sides of the excavation at 1.3 mg/kg. The excavation and removal of PCB-contaminated soil effectively remediated the site. There are no remaining environmental concerns at Site SS09.

7.9.5 Site Recommendations

The USAF issued a Final No Further Action Decision Document for Site SS09 in July 1991 (USAF 1991). ADEC concurred with the No Further Action alternative for this site in correspondence to the USAF dated December 1991 (ADEC 1991b). The USAF and ADEC consider Site SS09 closed.

7.10 SITE SS10-SOLVENT SPILL

7.10.1 Summary of Site Status

Site SS10-Solvent Spill is the former location where waste solvents reportedly were dumped at the White Alice Site. The site reportedly covered an approximate 10 by 20-foot area on the edge of a gravel pad. PCBs (Aroclor 1260) detected in soil at a maximum concentration of 25 mg/kg were the primary environmental concern at the site. During the 1989 Stage 2 RI/FS, approximately 9 cubic yards of contaminated soil were excavated and removed from the site. The USAF issued a Final No Further Action Decision Document for Site SS10 in July 1991. ADEC concurred with the No Further Action alternative for this site in correspondence to the USAF dated December 1991. The USAF and ADEC consider Site SS10 closed.

7.10.2 Site Description

Site SS10 is located at the White Alice Site, approximately 0.5 miles northwest of the Composite Facility (Figure 7-19). The site is the reported location where waste solvents were dumped at the White Alice Site. The site reportedly covered an approximate 10 by 20-foot area on the edge of a gravel pad, which drained to native tundra toward the north (see Figure 7-19). Neither permafrost nor suprapermafrost water was encountered at the site (USAF 1990a).

7.10.3 IRP Investigation Summary

Site SS10 was characterized during the 1988 Stage 1 RI/FS by advancing two shallow soil borings to approximately 2.5 feet below ground surface (USAF 1990a). A soil sample was collected from each boring and analyzed for petroleum hydrocarbons (Method 418.1 E), organochlorine pesticides and PCBs (Method SW 8080), and volatile organic compounds (Method SW 8240). A summary of maximum detected concentrations is provided in Section 3.2, Stage 1 RI/FS; Table 3-3. All sample locations were surveyed for elevation and horizontal coordinates (USAF 1990a).

Due to the detection of PCB (Aroclor 1260) in soil at a maximum concentration of 25 mg/kg, remedial activities were conducted in 1989 with the excavation and removal of PCB-contaminated soil at Site SS10 (USAF 1990b). The excavation was advanced to an approximate 10-foot radius and 2.7-foot depth, which contacted the native silt underlying the gravel pad. Approximately 9 cubic yards of soil were excavated and placed in 55-gallon drums and shipped to the DRMO at Elmendorf AFB, Alaska. Soil

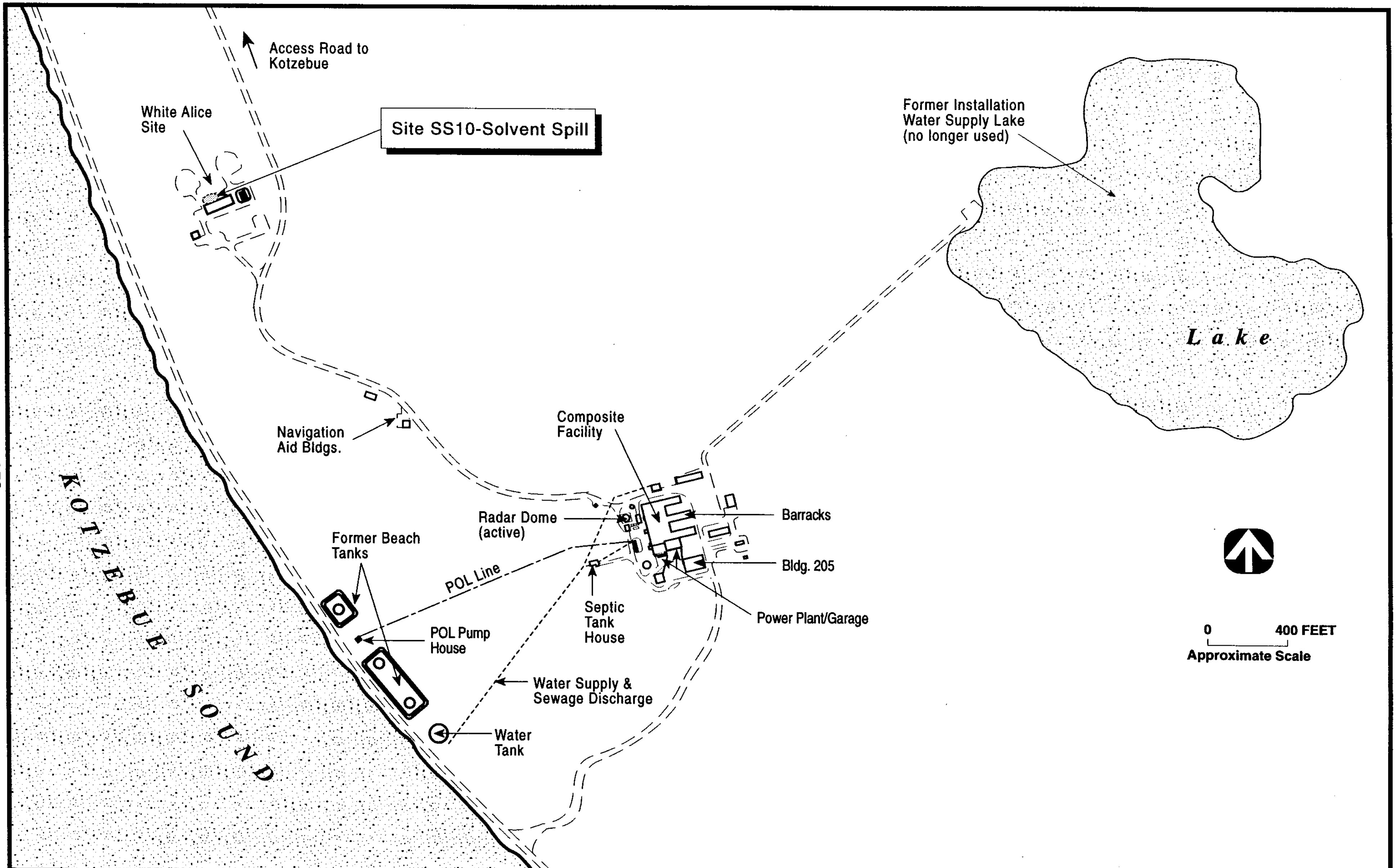


Figure 7-19. Location of Site SS10-Solvent Spill, Kotzebue LRRS, Alaska.

samples were collected from the sides and bottom of the excavation to confirm the removal of Aroclor 1260 in site soils (USAF 1990b).

7.10.4 Remaining Site Concerns

A target cleanup level of 10 mg/kg was established for PCBs in site soils at Kotzebue LRRS (USAF 1990b). Soil samples collected and composited to confirm the removal of PCBs during excavation indicated Aroclor 1260 below 10 mg/kg (USAF 1990b). The excavation and removal of PCB-contaminated soil effectively remediated the site. There are no remaining environmental concerns at Site SS10.

7.10.5 Site Recommendations

The USAF issued a Final No Further Action Decision Document for Site SS10 in July 1991 (USAF 1991). ADEC concurred with the No Further Action alternative for this site in correspondence to the USAF dated December 1991 (ADEC 1991b). The USAF and ADEC consider Site SS10 closed.

7.11 SITE SS11-FUEL SPILL

7.11.1 Summary of Site Status

Site SS11 is the reported location of a jet fuel spill which covered an approximate 50 by 60 foot area in native tundra. Petroleum hydrocarbons in soil (up to 23,000 mg/kg) was the primary environmental concern at the site. Remedial action (*in situ* enhanced bioremediation) initiated in 1988 and continued through the summer of 1990 reduced petroleum hydrocarbon contamination in soils to concentrations (i.e., 710 mg/kg) below the ADEC target level of 1,000 mg/kg for soils at Kotzebue LRRS. It is recommended that no further action is needed at Site SS11. A No Further Action Decision Document for Site SS11 will be submitted.

7.11.2 Site Description

Site SS11 is located at the White Alice Site approximately 0.5 miles northwest of the Composite Facility (Figure 7-20). The site is reportedly the location of a jet fuel spill which covered an approximate 50 by 60 foot area in native tundra. The site is located approximately 120 ft above sea level and is situated in a depression which is enclosed on three sides by gravel fill materials. Permafrost was encountered from 0.5 feet to 2.2 feet below ground surface (USAF 1990a). Ponded water covers a significant portion of the site. The site exhibits poor drainage; however, local surface drainage is suspected toward the east based on general site topography.

7.11.3 IRP Investigation Summary

Table 7-9 provides a summary of IRP activities. In 1988, the USAF conducted a Stage 1 RI/FS at Kotzebue LRRS which included the installation of four hand auger soil borings and the collection of three soil samples for analysis at Site SS11 (see Section 3.2, Stage 1 RI/FS; Table 3-3 for a summary of maximum detected concentrations). Remedial activities were initiated at the site in 1988 when native soils were mixed and aerated using a backhoe (USAF 1990a).

Due to the detection of petroleum hydrocarbons in soil at a maximum concentration of 23,000 mg/kg, remedial activities were continued in 1989 with the implementation of an *in situ* enhanced bioremediation pilot study at Site SS11. The pilot study included mixing approximately 24 cubic yards of clean, dry fill material (beach sands and gravel mixture) with the native soil to reduce the average moisture content and provide access for a backhoe and areal application of emulsification agents while mixing the amended

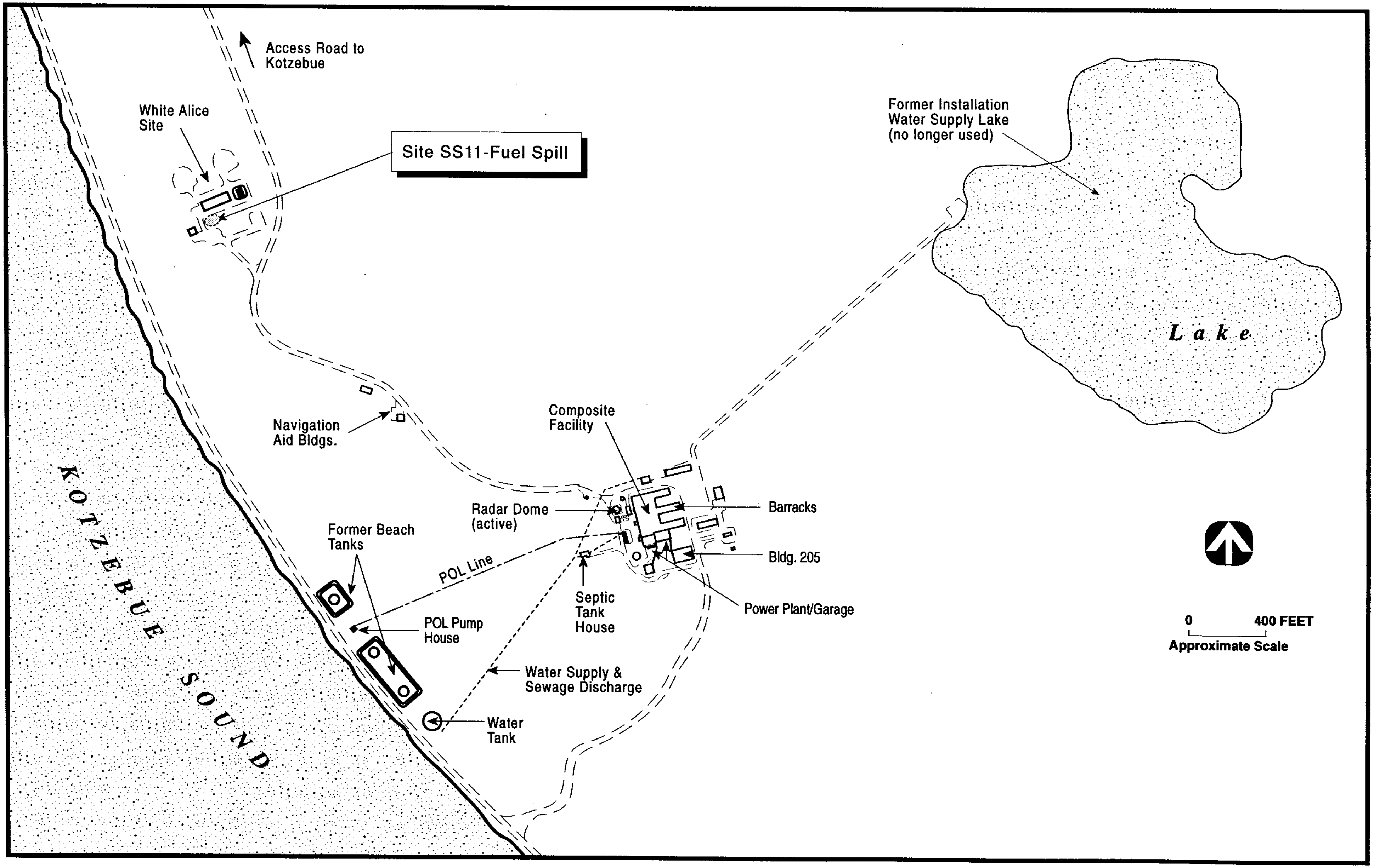


Figure 7-20. Location of Site SS11-Fuel Spill, Kotzebue LRRS, Alaska.

TABLE 7-9. SUMMARY OF IRP ACTIVITIES CONDUCTED AT SITE SS11-FUEL SPILL, KOTZEBUE LRRS, AK

Field Sampling	Analyses Performed	Field Activities
1988 Stage 1 RI/FS		
3 Soil Samples	TPH (Method E418.1) Volatile Organic Compounds (EPA Method 8240) Pesticides and PCBs (EPA Method 8080)	■ All sample locations surveyed ■ Site soils were mixed and aerated with a backhoe as an interim remedial action
1989-1990 Stage 2 RI/FS		
35 Soil Samples	TPH (Method E418.1)	■ *In situ* enhanced bioremediation pilot study. The pilot study included areal application of emulsification agents while mixing the amended soils with a backhoe
1994 Remedial Investigation		
4 Soil Samples	Diesel Range Organics (Method AK102) Volatile Organic Compounds (EPA Method 8260) Semivolatile Organic Compounds (EPA Method 8270) Pesticides and PCBs (EPA Method 8081)	■ All sample locations surveyed
1 Sediment Sample	Diesel Range Organics (Method AK102) Volatile Organic Compounds (EPA Method 8260) Semivolatile Organic Compounds (EPA Method 8270) Pesticides and PCBs (EPA Method 8081)	
1 Surface Water Sample	Diesel Range Organics (Method AK102) Volatile Organic Compounds (EPA Method 8260) Semivolatile Organic Compounds (EPA Method 8270) Pesticides and PCBs (EPA Method 8081)	

soils with a backhoe (USAF 1990b). Fifteen soil samples (i.e., three sampling events, with five soil samples per event) were collected during the 1989 pilot study. During the summer of 1990, the pilot study was continued and an additional 20 soil samples (i.e., two sampling events, with 10 soil samples per event) were collected to measure the effectiveness of the remedial action (see Table 7-9).

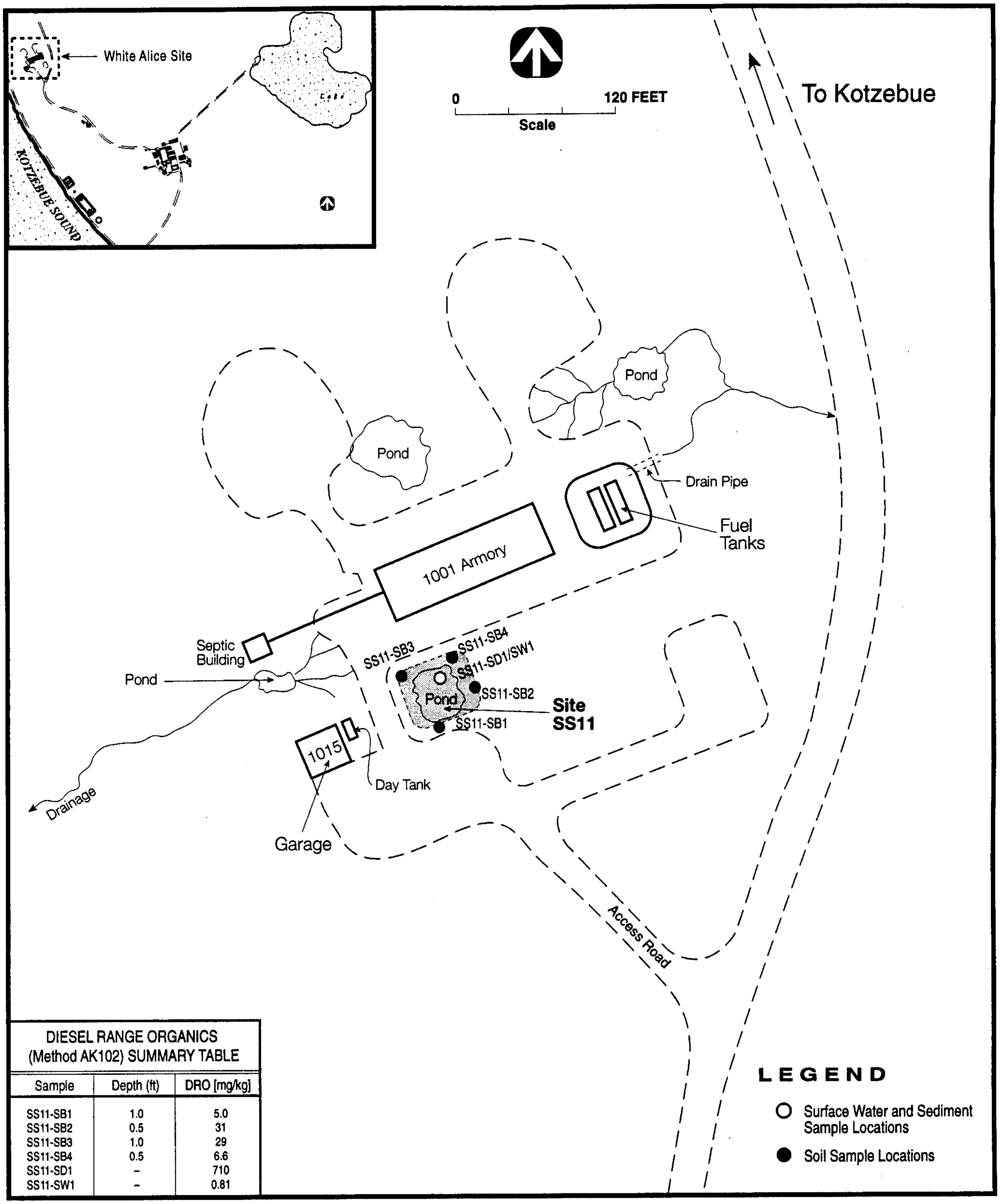
The results of the *in situ* pilot study indicated a significant reduction in the mean concentration of total petroleum hydrocarbon in soil (see Section 3.3, Stage 2 RI/FS; Table 3-6). Based on the measured progress at Site SS11, it was recommended that the pilot study be continued to more fully evaluate the effectiveness of bioremediation in Arctic environments for potential application at other Alaska IRP sites (USAF 1990b). However, no further remedial action was conducted at the site after the summer of 1990. In January of 1992, the ADEC indicated in correspondence to the Air Force, that the bioremediation effort at Site SS11 appeared to be progressing well and recommended the continuation of the bioremediation activities while monitoring its progress (ADEC 1992).

In 1994, a remedial investigation at Kotzebue LRRS was conducted which included the collection of four soil, one sediment, and one surface water samples at Site SS11 to characterize current site conditions (see Table 7-9). Figure 7-21 provides sample station locations at Site SS11. A summary of maximum detected concentrations identified at Site SS11 during the 1994 Remedial Investigation is provided in Section 4.5, Summary of Analytical Results; Tables 4-12 through 4-21. All sample analytical results for the 1994 RI are provided in Appendix L.

7.11.4 Remaining Site Concerns

Table 7-10 provides a summary of state and federal regulatory criteria (ARARs) and risk based criteria exceeded in the three media sampled at Site SS11: soil, sediment, and surface water. State and federal ARARs established to guide the 1994 Remedial Investigation are at least as stringent as those criteria developed during previous IRP investigations at Kotzebue LRRS (see Section 4.2, Applicable or Relevant and Appropriate Requirements).

7.11.4.1 Soil. Remedial actions initiated by the USAF in 1988 and continued through the summer of 1990 reduced petroleum hydrocarbon contamination in soils to concentrations below the current ADEC target level of 1,000 mg/kg for soils at Kotzebue LRRS (see Table 7-10).



DIESEL RANGE ORGANICS (Method AK102) SUMMARY TABLE

Sample	Depth (ft)	DRO [mg/kg]
SS11-SB1	1.0	5.0
SS11-SB2	0.5	31
SS11-SB3	1.0	29
SS11-SB4	0.5	6.6
SS11-SD1	-	710
SS11-SW1	-	0.81

Figure 7-21. Location of Sampling Stations at Site SS11-Fuel Spill, 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

TABLE 7-10. SUMMARY OF IRP CLEANUP CRITERIA EXCEEDANCE AT SITE SS11-FUEL SPILL, KOTZEBUE LRRS, AK

ARAR[a] Exceedance				Risk Based Exceedance (Human Health)				
Media	Chemical of Concern	Sample Concentration	ARAR Criteria	Media	Pathway	Chemical of Concern	Sample Concentration	Health Based Criteria[f]
1988 Stage 1 RI/FS								
Soil	TPH	23,000 mg/kg	10,000 mg/kg[b]	Not Evaluated				
	Total xylenes	200 mg/kg	50 mg/kg[b]					
1989-1990 Stage 2 RI/FS								
Soil	None	--	10,000 mg/kg[b]	Not Evaluated				
1994 Remedial Investigation								
Soil	None[c]	--	--	Soil	Ingestion	Arochlor 1260	2.7 mg/kg	1.08 mg/kg
Sediment	None[c]	--	--		Dermal contact	Arochlor 1260	2.7 mg/kg	0.13 mg/kg
Surface water	Diesel range organics	0.81 mg/L	0.015 mg/L[d]	Surface water	Dermal contact	Heptachlor epoxide	0.02 µg/L	0.0023 µg/L
	Heptachlor epoxide	0.02 µg/L	0.0010 µg/L[e]					
	4,4'-DDD	0.052 µg/L	0.0083 µg/L[e]			Beta-BHC	0.07 µg/L	0.002 µg/L

[a] Applicable or relevant and appropriate requirements.

[b] Stage 1 RI/FS recommended cleanup levels (USAF 1990a).

[c] No samples exceeded Alaska Department of Environmental Conservation petroleum hydrocarbon target level for soils of 1,000 mg/kg; or U.S. EPA Region 10 PCB cleanup criteria of 10 mg/kg.

[d] Alaska Department of Environmental Conservation; Water Quality Standards Regulations (18 AAC 70; January 1995).

[e] Federal Water Quality Criteria (State's compliance); protection of human health from the consumption of contaminated water, fish, and/or shellfish (U.S. EPA 1992, Federal Register Vol. 57, No. 246).

[f] Human health risk-based criteria established using 1994 Remedial Investigation results (USAF 1995b).

During the 1994 remedial investigation, the PCB Aroclor 1260 was detected in a single soil sample (SS11-SB4) at 2.7 mg/kg. The detection of Aroclor 1260 is likely associated with an adjacent site (Site SS09-PCBs Spill), which was a small PCB spill site remediated and closed during the 1989 Stage 2 RI/FS (USAF 1990b). In support of the 1994 remedial investigation, a baseline risk assessment was conducted. No unacceptable ecological risks were estimated for Site SS11. The health risk assessment indicated a potential risk to human health (i.e., $>10^{-6}$ risk) for both ingestion (1.95E-6) and dermal contact (1.63E-5) pathways, based on the detection of Aroclor 1260 in Site SS11 soil (USAF 1995b). The baseline risk assessment incorporated a number of conservative assumptions, including the frequency at which recreational and subsistence users may be exposed to contaminants (e.g., assumes exposure every day during the four summer months when contact with contaminants is not limited by frozen ground and/or snow cover). Based on the conservative nature of the baseline risk assessment, the limited detection of Aroclor 1260 at the site, and the fact that the concentration of Aroclor 1260 is below the U.S. EPA Region 10 PCB cleanup criteria established at 10 mg/kg for soil at Kotzebue LRRS (EPA 1987), no remedial action directed at PCBs is recommended.

7.11.4.2 Sediment. No cleanup criteria were exceeded based on the results from a single sediment sample (SS11-SD1) collected at Site SS11 during the 1994 remedial investigation (see Table 7-10).

7.11.4.3 Surface Water. Diesel range organics were detected at a concentration of 0.81 mg/L in a surface (ponded) water sample (SS11-SW1) collected at Site SS11 during the 1994 remedial investigation (see Figure 7-21). The detected level of DROs exceeds the 0.015 mg/L ADEC Water Quality Standard for petroleum hydrocarbons in surface water (ADEC 1995). However, any detection of DROs in surface waters at Kotzebue LRRS will exceed the ADEC Water Quality Criteria for petroleum hydrocarbons, as current laboratory analytical methods cannot obtain method detection limits at or below ADEC criteria. Due to the limited extent of ponded water at the site and the relatively low concentrations of DROs detected in both soils and surface water, it is recommended that no remedial action addressing surface water is warranted at this site. Natural attenuation processes such as photolysis, hydrolysis, sorption, and volatilization will act to reduce the remaining concentration of DROs in ponded site water (see Section 4.6.6, Natural Attenuation Assessment Results).

Pesticide compounds were ubiquitously detected at relatively low concentrations during the 1994 remedial investigation, including all background soil sample stations (see Section 4.5, Summary of Analytical

Results). The pesticides heptachlor epoxide and 4,4'-DDD were detected at relatively low concentrations at 0.02 μg/L and 0.052 μg/L, respectively (i.e., at or near laboratory practical quantitation limits), in surface water sample (SS11-SW1). However, these concentrations exceed federal water quality criteria of 0.0010 μg/L for heptachlor epoxide and 0.0083 μg/L for 4,4'-DDD established for the state of Alaska, based on the protection of human health from the consumption of contaminated water, fish, and/or shellfish (EPA 1992; see Table 7-10). In support of the 1994 remedial investigation, a baseline risk assessment was conducted which indicates no ecological risk based criteria were exceeded based on surface water sample results for Site SS11. The health risk assessment identified a potential risk to human health (i.e., $> 10^{-6}$ risk) for dermal contact with ponded site water (4.4E-6) based on the detection of heptachlor epoxide at 0.02 μg/L and (3.05E-6) based on the detection of Beta-BHC at 0.07 μg/L. The surface water sample SS11-SW1 was collected from an area of ponded water approximately 20 by 30 feet and approximately 2.5 ft deep (see Figure 7-10). Because ponded water at Site SS11 is limited in extent, does not represent a potential drinking water source for humans, and has relatively low concentrations of both heptachlor epoxide and 4,4'-DDD, further remedial action is not considered warranted at this site.

7.11.5 Site Recommendations

Based on past IRP activities conducted at Site SS11, the remaining levels of contaminants detected, and a review of associated ARARs and baseline risk assessment information, it is recommended that no further action is needed at Site SS11-Fuel Spill. A No Further Action Decision Document for Site SS11 will be submitted.

7.12 SITE SS12-SPILLS NO. 2 AND 3

7.12.1 Summary of Site Status

Site SS12-Spills No. 2 and 3 is located west-southwest of the Composite Facility and is comprised of two diesel fuel spill locations (Spills No. 2 and 3) which have commingled. Petroleum hydrocarbons in soil (up to 53,000 mg/kg) and in ponded surface water (at 8.8 mg/L) are the primary environmental concerns at the site. Based on the concentration of diesel range organics remaining in gravel fill materials at Site SS12, remedial action is recommended, including excavation and removal of contaminated fill materials which currently exceed the ADEC soil target level of 1,000 mg/kg. Onsite treatment of contaminated fill materials removed from Site SS12 is recommended to reduce petroleum hydrocarbon concentrations to levels acceptable for the onsite disposal of treated soils. Limited remedial actions are recommended for native tundra impacted at the site, including natural attenuation and long-term soil and/or surface water monitoring to measure the reduction in petroleum hydrocarbon contamination. The natural attenuation and long-term monitoring alternative represents a non-invasive, non-destructive alternative to material removal actions or other approaches that would negatively impact the fragile tundra environment and local ecosystem.

7.12.2 Site Description

Site SS12 is located west-southwest of the Composite Facility (Figure 7-22). The site is comprised of two diesel fuel spill areas (Spills No. 2 and 3) which have commingled. Spill No. 2 is the location of a reported diesel fuel spill which occurred in 1979-1980 when a day tank behind the facility's power plant was overfilled (USAF 1985). Spill No. 2 reportedly covered an area approximately 40 feet by 80 feet in gravel fill materials; however, no information regarding the volume of diesel fuel released at Spill No. 2 is available. Absorbent materials were reportedly used by the USAF to cleanup the fuel remaining on the ground surface (USAF 1985). The Spill No. 2 area is generally flat, but begins to slope moderately to the southwest at its western boundary. Surface and subsurface drainage is toward the southwest. The gravel pad underlying Spill No. 2 was reportedly 2 to 2.5 feet thick. Permafrost was encountered at approximately 5 feet below ground surface during a previous investigation (USAF 1990a).

Spill No. 3 is an estimated 1.5 acre diesel fuel spill located adjacent to, and southwest of, the Composite Facility (see Figure 7-22). The site is the reported location of a large diesel fuel spill which occurred via a hole in a distribution line identified in 1984 (USAF 1985). The fuel line was repaired, and approxi-

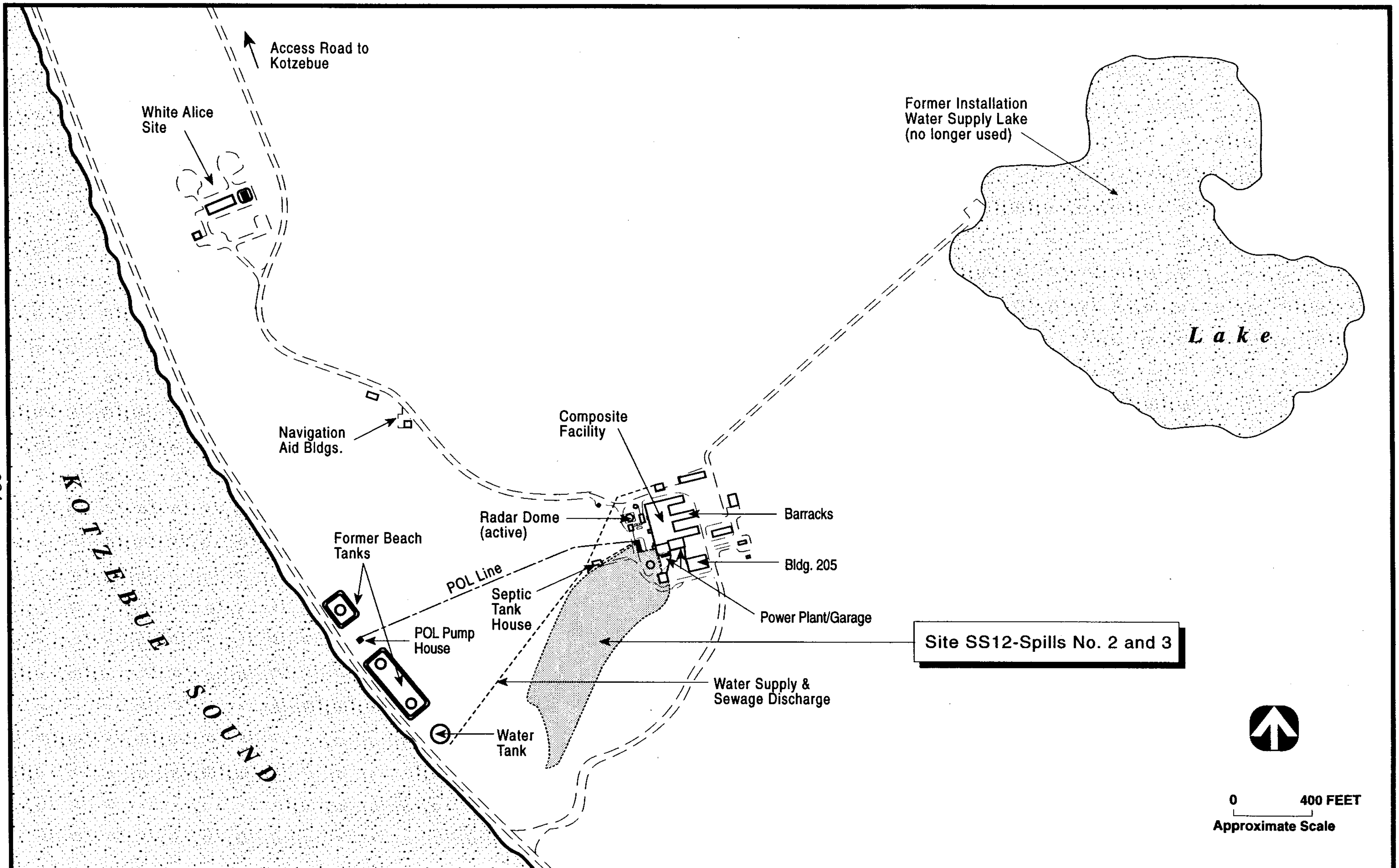


Figure 7-22. Location of Site SS12-Spills No. 2 and 3, Kotzebue LRRS, Alaska.

mately 4,000 gallons of diesel fuel was reportedly collected in recovery trenches subsequently installed by the USAF. The Spill No. 3 area extends from the gravel pad adjacent to the facility's power plant (at an approximate elevation of 140 feet above sea level), over native tundra vegetation which slopes moderately to the southwest, to the base of the tundra hill at an approximate elevation of 12 feet above sea level and approximately 1,200 feet from the reported source (see Figure 7-22).

Relatively large areas of stressed and dead vegetation were reported as a result of diesel fuel released during Spill No. 3. However, a recent investigation at Site SS12 shows that revegetation is occurring along the hillslope of the Spill No. 3 site, indicating that the fragile tundra environment is undergoing natural restoration. Native tundra impacted by Spill No. 3 is characterized by a tundra mat (organic tundra roots and moss) from 0 to 0.75 feet below ground surface, which overlies grey silt. Permafrost is shallow and was encountered at between 0.5 and 1.5 feet below ground surface during previous site investigations conducted in native tundra at Site SS12. Surface water occurrence at Site SS12 is limited to relatively shallow depressions in native tundra which act to pond water along the tundra hill down-gradient of the installation. The largest surface water body is formed by the former interception trench installed to capture fuel released during Spill No. 3.

7.12.3 IRP Investigation Summary

IRP activities at SS12 included investigations and remedial actions, and a separate natural attenuation assessment.

7.12.3.1 Investigations and Remedial Actions. Table 7-11 provides a summary of IRP investigation activities conducted at Site SS12. During the 1988 Stage 1 RI/FS, three test pits were installed and six soil samples were collected for analysis at the Spill No. 2 site. One surface water sample, 24 soil samples, and 40 soil gas samples were collected at the Spill No. 3 site during the Stage 1 RI/FS (see Table 7-11). A soil gas survey was conducted at Spill No.3 to provide an assessment of the extent of petroleum contamination adjacent to the site. However, the soil gas survey data were reportedly non-quantifiable, primarily due to the extreme variability of soil moisture content (USAF 1990a). A summary of maximum detected concentrations is provided in Section 3.2, Stage 1 RI/FS; Table 3-3. Five water-flooding pilot studies were conducted at the Spill No. 3 site in an attempt to recover free product from contaminated soils (USAF 1990a). Results of the water-flooding pilot studies indicated that water-

TABLE 7-11. SUMMARY OF IRP ACTIVITIES CONDUCTED AT SITE SS12-SPILLS NO. 2 AND 3, KOTZEBUE LRRS, ALASKA

Field Sampling	Analyses Performed	Field Activities
1988 Stage 1 RI/FS		
Spill No. 2 6 Soil Samples	Petroleum Hydrocarbons (EPA Method E 418.1) Volatile Organic Compounds (EPA Method SW 8260) Organochlorine Pesticides and PCBs (EPA Method SW 8081)	■ All samples locations were surveyed ■ Three test pits were installed to collect soil samples
Spill No. 3 21 Soil Samples	Petroleum Hydrocarbons (EPA Method E 418.1) Volatile Organic Compounds (EPA Method SW 8260) Organochlorine Pesticides and PCBs (EPA Method SW 8081)	■ All sample locations were surveyed (including soil gas monitoring stations) ■ 16 shallow hand auger borings were installed ■ 5 water-flood pilot studies conducted to evaluate product recovery ■ 40 soil gas monitoring stations installed and tested
1 Surface Water Sample	Petroleum Hydrocarbons (Method E 418.1) Purgeable Aromatics (EPA Method SW 8020) Purgeable Halocarbons (EPA Method SW 8010) Lead (total and dissolved) (EPA Method SW 7421)	
40 Soil Gas Monitoring Stations	Total Petroleum Hydrocarbons measured in (PPMV) during soil gas survey	
1989-1990 Stage 2 RI/FS		
Spill No. 2 None	None	■ Three treatment infiltration trenches were installed to conduct *in situ* enhanced bioremediation around existing piping, tanks, and fencing ■ Approximately 100 yd^3 of petroleum contaminated fill material was excavated and placed in a nearby landfarm cell
Spill No. 3 35 Soil Samples (Native Tundra)	Petroleum Hydrocarbons (Method E 418.1)	■ *In situ* enhanced bioremediation activities were conducted in native tundra ■ Approximately 350 yd^3 of petroleum contaminated soils were excavated and placed in a nearby landfarm cell
1994 Remedial Investigation (Spill No. 2 and 3)		
38 Soil Samples	(38) Diesel Range Organics (Method AK102) (11) Volatile Organic Compounds (EPA Method SW 8260) (11) Semivolatile Organic Compounds (EPA Method SW 8270) (10) Pesticides and PCBs (EPA Method SW 8081)	■ All sample locations were surveyed ■ A natural attenuation assessment was conducted for both soil and surface water at the site
2 Sediment Samples	Diesel Range Organics (Method AK102) Volatile Organic Compounds (EPA Method SW 8260) Semivolatile Organic Compounds (EPA Method SW 8270) Pesticides and PCBs (EPA Method SW 8081)	
4 Surface Water Samples	Diesel Range Organics (Method AK102) Volatile Organic Compounds (EPA Method SW 8260) Semivolatile Organic Compounds (EPA Method SW 8270) Pesticides and PCBs (EPA Method SW 8081)	

flooding was not a viable remedial alternative. This conclusion was based on inadequate volumes of free-product at the site and the low permeability of site soils (USAF 1990a).

Due to the detection of petroleum hydrocarbons in soil at Spill No. 2 and 3 at a maximum concentration of 10,700 mg/kg and 99,200 mg/kg, respectively, remedial actions were initiated at both sites in 1989 with the implementation of in situ enhanced bioremediation and excavation and removal of contaminated soils (USAF 1990b). Approximately 100 cubic yards of petroleum contaminated soil (fill material) were excavated from the Spill No. 2 site and placed in a nearby landfarm cell for ex situ bioremediation treatment. Approximately 50 cubic yards of clean backfill was placed in the excavation and graded. An *in situ* enhanced bioremediation pilot study was implemented at Spill No. 2 to address petroleum hydrocarbon contaminated soil around tanks, tank piping, and fencing which were unaccessible during excavation. The pilot study included the installation of three shallow (3 to 4 feet deep) infiltration trenches which were filled with emulsification and nutrient agent solutions. The trenches were backfilled with site soils once the fluids had infiltrated the gravel fill. The pilot study did not involve soil sampling to confirm the effectiveness of the remedial action (USAF 1990b).

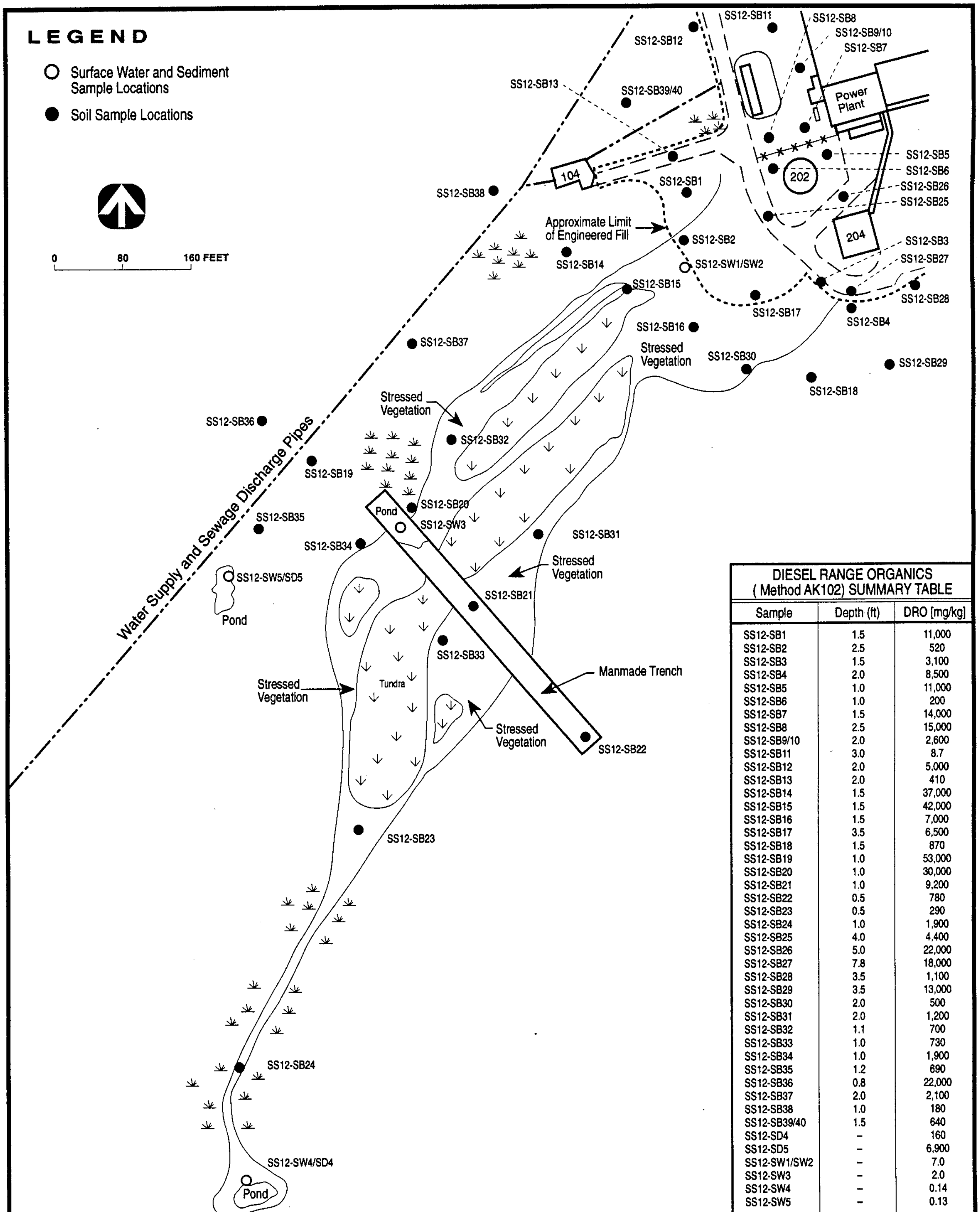
Remedial actions conducted at Spill No. 3 during the 1989-1990 Stage 2 RI/FS included the excavation of approximately 350 cubic yards of petroleum hydrocarbon contaminated soil which were placed in a nearby landfarm for ex situ bioremediation treatment (USAF 1990b). The lateral limits of the excavation were constrained to the west by an undisturbed tundra slope and to the north and east by existing roadways. Approximately 250 cubic yards of clean backfill were reportedly placed in the excavation and graded to conform with the surrounding topography. In 1989, an *in situ* enhanced bioremediation study was conducted at Spill No. 3 to address residual diesel fuel contamination detected in native tundra at the site (USAF 1990b). The bioremediation study included aerial applications of emulsifiers and micro-nutrients during the 1989 and 1990 field seasons. Fifteen soil samples (e.g., three sampling events, with five soil samples per event) were collected in 1989 and 20 soil samples (e.g., two sampling events, with 10 soil samples per event) were collected in 1990 from treated areas in native tundra to evaluate the effectiveness of the remedial action (see Table 7-11). The petroleum hydrocarbon concentrations in native soil at Spill No. 3 reportedly revealed a mean reduction from 7,500 mg/kg in August 1989 to 1,306 mg/kg in September 1990. However, the mean reduction in petroleum hydrocarbon concentrations observed in native tundra must be reviewed with caution due to the limited number of soil locations sampled and the uneven distribution of petroleum hydrocarbons across the site (USAF 1990b). The

results of the *in situ* enhanced bioremediation study are summarized in Section 3.3, Stage 2 RI/FS; Table 3-6.

Based on the results of the 1989-1990 Stage 2 RI/FS, follow-on action was recommended at Spill No. 2, including remedial action around existing pipelines, tanks, roadways, and fencing. The continuation of the *in situ* enhanced bioremediation pilot study on native tundra at Spill No. 3 was also recommended. However, no further remedial action has been conducted at Site SS12-Spills No. 2 and 3 since the summer of 1990.

In correspondence to the USAF dated January 1992, ADEC indicated that during a recent site inspection, a fuel seep appeared to originate from the Spill No. 2 site and diesel fuel contamination remained at the site at unknown concentrations due to site structures restricting the removal of contaminated soils (ADEC 1992). ADEC recommended that the USAF determine the extent of petroleum hydrocarbon contamination at the Spill No. 2 site prior to proceeding with remedial action. ADEC stated in the same correspondence that the bioremediation efforts at the Spill No. 3 site appeared to be progressing well, recommending the continuation of bioremediation activities while monitoring the progress (ADEC 1992). In 1993, ADEC indicated in correspondence to the USAF that ongoing hazardous substance releases at Kotzebue LRRS potentially represent violations of Alaska statutes and regulations, and requested USAF notification regarding remedial action work plans for the site (ADEC 1993). In 1994, USAF issued an IRP Work Plan for Kotzebue LRRS which provided the outline for work to be conducted during the 1994 RI at Kotzebue LRRS (USAF 1994a).

Site SS12 was further characterized during the 1994 RI, including the definition of suspected contaminant source areas in gravel fill materials and characterization of the lateral and vertical extent of contamination. Ponded surface water and sediment at the site was also selectively characterized, based on visual observations (e.g., presence of oil sheen), to evaluate potential migration downgradient of suspected source areas. The site characterization also included a natural attenuation assessment of site surface water and soil to determine if natural attenuation processes are actively occurring. A total of 38 soil samples, 4 surface water samples, and 2 sediment samples were collected for analysis (see Table 7-11). Figure 7-23 provides the 1994 sample station locations at Site SS12. A summary of maximum detected concentrations identified at Site SS12 during the 1994 RI is provided in Section 4.5, Summary of



DIESEL RANGE ORGANICS
(Method AK102) SUMMARY TABLE

Sample	Depth (ft)	DRO [mg/kg]
SS12-SB1	1.5	11,000
SS12-SB2	2.5	520
SS12-SB3	1.5	3,100
SS12-SB4	2.0	8,500
SS12-SB5	1.0	11,000
SS12-SB6	1.0	200
SS12-SB7	1.5	14,000
SS12-SB8	2.5	15,000
SS12-SB9/10	2.0	2,600
SS12-SB11	3.0	8.7
SS12-SB12	2.0	5,000
SS12-SB13	2.0	410
SS12-SB14	1.5	37,000
SS12-SB15	1.5	42,000
SS12-SB16	1.5	7,000
SS12-SB17	3.5	6,500
SS12-SB18	1.5	870
SS12-SB19	1.0	53,000
SS12-SB20	1.0	30,000
SS12-SB21	1.0	9,200
SS12-SB22	0.5	780
SS12-SB23	0.5	290
SS12-SB24	1.0	1,900
SS12-SB25	4.0	4,400
SS12-SB26	5.0	22,000
SS12-SB27	7.8	18,000
SS12-SB28	3.5	1,100
SS12-SB29	3.5	13,000
SS12-SB30	2.0	500
SS12-SB31	2.0	1,200
SS12-SB32	1.1	700
SS12-SB33	1.0	730
SS12-SB34	1.0	1,900
SS12-SB35	1.2	690
SS12-SB36	0.8	22,000
SS12-SB37	2.0	2,100
SS12-SB38	1.0	180
SS12-SB39/40	1.5	640
SS12-SD4	-	160
SS12-SD5	-	6,900
SS12-SW1/SW2	-	7.0
SS12-SW3	-	2.0
SS12-SW4	-	0.14
SS12-SW5	-	0.13

Figure 7-23. Location of Sample Stations at Site SS12-Spills No. 2 and No. 3, 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

Analytical Results; Tables 4-12 through 4-21. All sample analytical results for the 1994 RI are provided in Appendix L.

7.12.3.2 Natural Attenuation Assessment. During the 1994 RI, data were obtained from soil and ponded surface water at Site SS12 to specifically address whether natural attenuation is actively occurring, and to what extent biodegradation may be responsible for the reduction of petroleum hydrocarbon concentrations at Kotzebue LRRS. A suite of geochemical parameters was measured in surface water samples both upgradient and downgradient of the Spill No. 2 and 3 source areas to document the relationship between surface water geochemistry and contaminant chemistry, allowing an evaluation of the effect of natural attenuation processes on surface water associated with Site SS12. Additionally, site soils were evaluated using carbon chain ratios (straight chain/branched chain) to determine the difference in composition between fresh diesel fuel and degraded diesel fuel detected in site soils (see Section 4.4.9, Natural Attenuation Assessment).

Results of the natural attenuation assessment at Site SS12 indicate that natural attenuation is actively occurring in site soils, and that biodegradation may be a significant process acting to reduce petroleum hydrocarbon concentrations over time. Diesel range organics concentrations detected in surface waters at Site SS12 decreased significantly from upgradient to downgradient samples, as does total organic carbons. These trends indicate that natural attenuation processes are acting to reduce petroleum hydrocarbon concentrations with distance from the source. However, geochemical trends observed in site surface water did not support a biological process to account for the reduced petroleum hydrocarbon concentrations. Taken as a whole, the data for the surface water flow path indicated that other attenuation processes such as photolysis, hydrolysis, or abiotic oxidation may be responsible for the observed reduced diesel range organics concentrations. Alternatively, purely physical processes such as sorption, volatilization, or dilution may account for the observed diesel range organics concentrations (see Section 4.6.6, Natural Attenuation Assessment Results).

7.12.4 Remaining Site Concerns

Table 7-12 provides a summary of state and federal regulatory criteria (ARARs) and risk based criteria exceeded in soil, sediment, and surface water samples collected at Site SS12. State and federal ARARs established to guide the 1994 RI are at least as stringent as those criteria developed during previous IRP

TABLE 7-12. SUMMARY OF IRP CLEANUP CRITERIA EXCEEDANCE AT SITE SS12-SPILLS NO. 2 AND 3, KOTZEBUE LRRS, ALASKA

ARAR[a] Exceedance				Risk Based Exceedance[f]									
				Human Health					Ecological				
Media	Chemical of Concern	Sample Concentration	ARAR Criteria	Media	Pathway	Chemical of Concern	Sample Concen-tration	Health-Based Criteria	Media	Pathway	Chemical of Concern	Sample Concen-tration	Ecological Criteria
1988 Stage 1 RI/FS													
Soil	Petroleum Hydrocarbon	99,200 mg/kg	10,000 mg/kg[b]	Not Evaluated					Not Evaluated				
	Total Xylene	170 mg/kg	50 mg/kg[b]										
1994 Remedial Investigation													
Soil	Diesel Range Organics	53,000 mg/kg	1,000 mg/kg[c]	Soil	Dermal contact	Aroclor 1260	0.96 mg/kg	0.13 mg/kg	Soil	Dietary	Total Xylene	440 mg/kg	2.6 mg/kg
											2-Methyl-naphthalene	95 mg/kg	6.6 mg/kg
Surface Water	Diesel Range Organics	8.8 mg/L	0.015 mg/L[d]	Surface water	Dermal contact	Heptachlor epoxide	0.3 µg/L	0.0045 µg/L					
	4,4'-DDD	0.075 µg/L	0.0083 µg/L[e]										
	4,4'-DDT	0.094 µg/L	0.0059 µg/L[e]										
	Dieldrin	0.03 µg/L	0.0014 µg/L[e]										
	Heptachlor epoxide	0.3 µg/L	0.0010 µg/L[e]										
	Aldrin	0.05 µg/L	0.0013 µg/L[e]										
	Heptachlor	0.05 µg/L	0.0021 µg/L[e]										
	Beta-BHC	0.19 µg/L	0.14 µg/L[e]										
	Alpha-BHC	0.13 µg/L	0.039 µg/L[e]										

[a] Applicable or relevant and appropriate requirements.
[b] Stage 1 RI/FS recommended cleanup levels (USAF 1990a).
[c] Alaska Department of Environmental Conservation; Petroleum hydrocarbon target level of 1,000 mg/kg for soils at Kotzebue LRRS.
[d] Alaska Department of Environmental Conservation; Water Quality Standards Regulations (18 AAC 70; January 1995).
[e] Federal Water Quality Criteria (State's compliance); protection of human health from the consumption of contaminated water, fish, and/or shellfish (U.S. EPA 1992, Federal Register Vol. 57, No. 246).
[f] Human health and ecological risk based criteria established using 1994 Remedial Investigation results (USAF 1995b).

investigations at Kotzebue LRRS (see Section 4.2, Applicable or Relevant and Appropriate Requirements).

7.12.4.1 Soil. During the 1994 RI, 15 subsoil samples (including SS12-SB1, SB2, SB3, SB4, SB5, SB6, SB7, SB8, SB9, SB11, SB12, SB13, SB25, SB26, SB27, and SB28) were collected to characterize fill materials associated with Site SS12. Of these 15 soil samples, 12 revealed diesel range organics concentrations above the 1,000 mg/kg ADEC soil target level, with a maximum concentration of 22,000 mg/kg detected in Sample SS12-SB26 at a depth of five feet below ground surface (see Figure 7-23). Twenty-three shallow subsoil samples were collected within the native tundra vegetation downgradient of the installation. Fourteen of the 23 samples submitted for diesel range organic analysis revealed elevated concentrations, exceeding the ADEC petroleum hydrocarbon target level for soils at Kotzebue LRRS (see Figure 7-23). Sample SS12-SB19 produced a maximum diesel range organics concentration of 53,000 mg/kg. Results of the natural attenuation assessment indicate that natural attenuation is actively occurring in site soils, and that biodegradation may be a significant process acting to reduce petroleum hydrocarbon concentrations over time (see Section 4.6.6, Natural Attenuation Assessment Results).

In support of the 1994 RI, a baseline risk assessment was conducted which indicates a potential risk to human health (i.e., $>10^{-6}$ risk) for the dermal contact pathway at Site SS12, based on the detection of PCB (Aroclor 1260) in one of 39 soil samples collected at 0.96 mg/kg in Sample SS12-SB9/10 (see Figure 7-23). The baseline risk assessment also indicated a potential ecological risk for the dietary pathway at Site SS12 (i.e., HQ >1) based on the detection of total xylenes in two samples, including SS12-SB7 at 18 mg/kg and SS12-SB27 at 440 mg/kg. A potential ecological risk was also indicated for the dietary pathway based on the detection of 2-methylnaphthalene in four samples, including SS12-SB1 at 9.6 mg/kg, SS12-SB7 at 95 mg/kg, SS12-SB16 at 7.6 mg/kg, and SS12-SB27 at 64 mg/kg. All soil samples identified to pose a potential ecological or human health risk at Site SS12 were collected from areas within gravel fill materials at the site (see Figure 7-23).

7.12.4.2 Sediment. During the 1994 RI, two sediment samples (SS12-SD4 and SD5) were collected at Site SS12. Diesel range organics were detected in Sample SS12-SD4 at 160 mg/kg and in Sample SS12-SD5 at 6,900 mg/kg (see Figure 7-23). Sample SS12-SD5 exceeds the 1,000 mg/kg ADEC soil target level for soils at Kotzebue LRRS.

7.12.4.3 Surface Water. Diesel range organics were detected in all four surface water samples collected during the 1994 RI, with a maximum concentration of 8.8 mg/L detected in Sample SS12-SW1 (see Figure 7-23). The detected levels of DROs exceed the 0.015 mg/L ADEC Water Quality Criteria for petroleum hydrocarbons in surface water (ADEC 1995). However, any detection of DROs in surface waters at Kotzebue LRRS will exceed the ADEC Water Quality Criteria for petroleum hydrocarbons, as current laboratory analytical methods cannot obtain method detection limits at or below ADEC criteria. Surface water occurrence at Site SS12 is limited to relatively shallow depressions in native tundra which act to pond water along the tundra hill downgradient of the installation. The largest surface water body (approximately 1,500 square feet) is formed by the former interception trench installed to capture fuel released during Spill No. 3 (see Figure 7-23). Natural attenuation processes such as photolysis, hydrolysis, sorption, and volatilization are acting to reduce concentrations of DROs in ponded site water over time, providing DROs do not continue to migrate from potential upgradient sources.

The pesticides 4,4'-DDD, 4,4'-DDT, dieldrin, heptachlor epoxide, aldrin, heptachlor, beta-BHC, and alpha-BHC were all detected in surface water samples collected at the site and exceed federal water quality criteria established for the State of Alaska, based on the protection of human health from the consumption of contaminated water, fish, and/or shellfish (EPA 1992; see Table 7-12). No ecological risk based criteria were exceeded based on surface water sample results for Site SS12. The health risk assessment indicates a potential risk to human health (i.e., $>10^{-6}$ risk) for dermal contact with ponded water (5.4E-6) based on the detection of heptachlor epoxide at a maximum concentration of 0.3 μg/L in Sample SS12-SW1. However, ponded surface water at Site SS12 is limited in extent and does not represent a potential drinking water source for humans. Additionally, pesticide compounds were ubiquitously detected at relatively low concentrations during the 1994 RI, including all background soil sample stations (see Section 4.5, Summary of Analytical Results).

7.12.5 Site Recommendations

Based on the concentration of diesel range organics remaining in gravel fill materials at Site SS12, remedial action is recommended, including excavation and removal of contaminated fill materials which currently exceed the ADEC soil target level of 1,000 mg/kg. The removal of contaminated fill materials to concentrations below the ADEC soil target level will incorporate soils from those locations which indicated potential ecological or human health risk (see Section 7.12.4.1, Soil). Onsite treatment of contaminated fill materials removed from Site SS12 is recommended to reduce petroleum hydrocarbon

concentrations to levels acceptable for the onsite disposal of treated soils. The estimated 11,000 cubic yards of contaminated material at or above the 1,000 mg/kg ADEC soil target level are located in an area 250 by 240 feet, with a depth of 5.0 feet (Figure 7-24).

Native tundra located downgradient of gravel fill materials (petroleum hydrocarbon source) at Site SS12 exhibits elevated concentrations (i.e., > 1,000 mg/kg) of diesel range organics (see Figure 7-24). Limited remedial actions are recommended in native tundra impacted by Site SS12, including natural attenuation and long-term soil and surface water monitoring to measure the reduction in petroleum hydrocarbon contamination. The natural attenuation and long-term monitoring alternative represents a non-invasive, non-destructive alternative to material removal actions or other approaches that would negatively impact the fragile tundra environment and local ecosystem. The natural attenuation alternative for native tundra at Site SS12 is supported by the following:

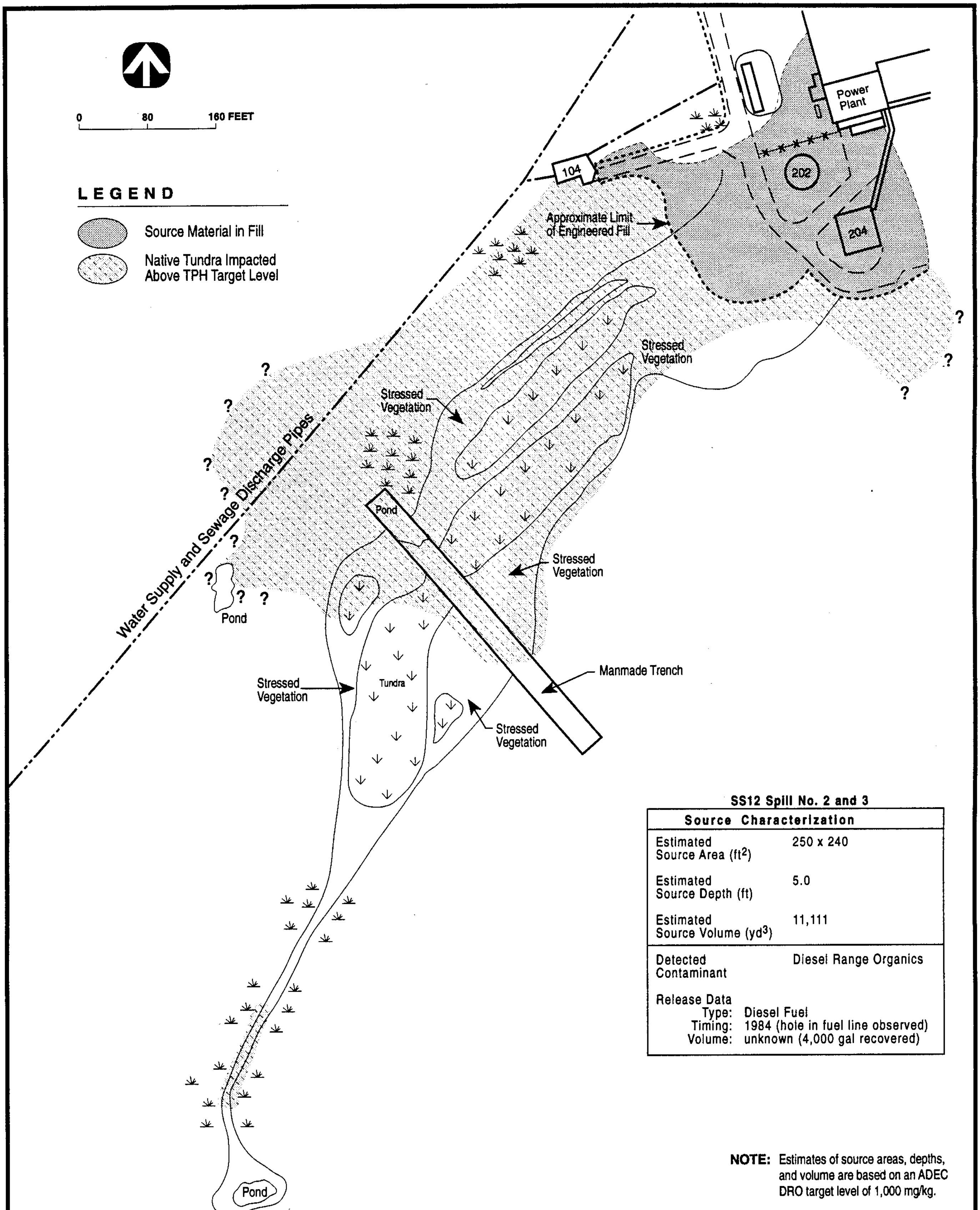
- A quantitative baseline evaluation of ecological and human health risks associated with the site was performed based on information obtained during the 1994 RI. The baseline risk assessment indicates that no unacceptable risks were estimated in soils associated with the native tundra at Site SS12.

- The excavation and removal of contaminated fill materials from Site SS12 will eliminate the ongoing release of petroleum hydrocarbons to the nearby native tundra environment.

- A natural attenuation assessment conducted at Site SS12 indicates that natural attenuation is actively occurring in both soils (native tundra) and surface waters at Site SS12.

- The revegetation occurring along the hillslope of the Spill No. 3 site is an indication that the fragile tundra environment is undergoing natural restoration.

Biannual monitoring is recommended for native tundra impacted at Site SS12, including visual inspection and photodocumentation to demonstrate the natural restoration (revegetation) occurring at the site. Biannual monitoring should also incorporate limited surface water and soil sample collection for diesel range organics to evaluate the effectiveness of the natural attenuation alternative. Surface water sample(s) should be collected from ponded site water previously characterized during the 1994 RI to assure appro-



SS12 Spill No. 2 and 3

Source Characterization	
Estimated Source Area (ft^2)	250 x 240
Estimated Source Depth (ft)	5.0
Estimated Source Volume (yd^3)	11,111
Detected Contaminant	Diesel Range Organics
Release Data Type: Timing: Volume:	 Diesel Fuel 1984 (hole in fuel line observed) unknown (4,000 gal recovered)

NOTE: Estimates of source areas, depths, and volume are based on an ADEC DRO target level of 1,000 mg/kg.

Figure 7-24. DRO Contaminant Source Characterization at Site SS12 Spills No. 2 and No. 3, 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

priate comparison of DRO concentrations between monitoring events. Similarly, soil sample(s) should be collected from previous sample locations (in tundra) which revealed elevated DRO concentrations. Data obtained from biannual monitoring should be evaluated to determine the effectiveness of natural attenuation and to assess the need and/or requirements for subsequent monitoring of Site SS12.

7.13 SITE SS13-LANDFARM (AOC1)

7.13.1 Summary of Site Status

Site SS13-Landfarm (AOC1) is a landfarm site constructed during the 1989-1990 Stage 2 RI/FS to remediate petroleum hydrocarbon contaminated soil at Kotzebue LRRS. The site was constructed on a level pad (part concrete and part fill) designed to contain approximately 500 cubic yards of petroleum hydrocarbon contaminated soils. The site is located on the east side of the installation access road, directly east of the Composite Facility. Petroleum hydrocarbons detected in landfarm soil (up to 5,100 mg/kg), adjacent soil (up to 4,800 mg/kg), and surface water (at 2.0 mg/L) are the primary environmental concern at Site SS13. It is suspected that infiltration and runoff from the site has impacted native vegetation immediately downgradient (east) of the site. To mitigate further potential impacts to native tundra, it is recommended that contaminated landfarm soil and fill material be excavated and removed from Site SS13. Onsite treatment of contaminated fill materials is recommended to reduce petroleum hydrocarbon concentrations to acceptable levels for the onsite disposal of treated soil. Limited action is recommended for native soils impacted by the site, including natural attenuation and long-term monitoring to evaluate environmental restoration once source materials have been removed from the site. The natural attenuation and long-term monitoring alternative represent a non-invasive, non-destructive alternative to material removal or other approaches that would negatively impact the fragile tundra environment.

7.13.2 Site Description

Site SS13 is a landfarm site constructed during the 1989-1990 Stage 2 RI/FS to remediate petroleum hydrocarbon contaminated soil at Kotzebue LRRS. The site was constructed on a level pad on the east side of the installation access road, directly east of the Composite Facility (Figure 7-25). Petroleum hydrocarbon contaminated soil (approximately 500 cubic yards) was excavated from three locations at Kotzebue LRRS and stockpiled on 6 mil plastic within the landfarm area. A soil berm was constructed around the landfarm cell to contain contaminated soil and restrict runoff. The landfarm has not been maintained since the 1990 field program and recent site survey observations indicated no landfill cover or access restriction exist at the site.

Site SS13 is located at an approximate elevation of 147 feet above sea level. The eastern boundary of the landfarm site slopes moderately east to northeast, toward the former water supply lake located approximately 0.5 mile northeast of the site and at an approximate elevation of 40 feet above sea level

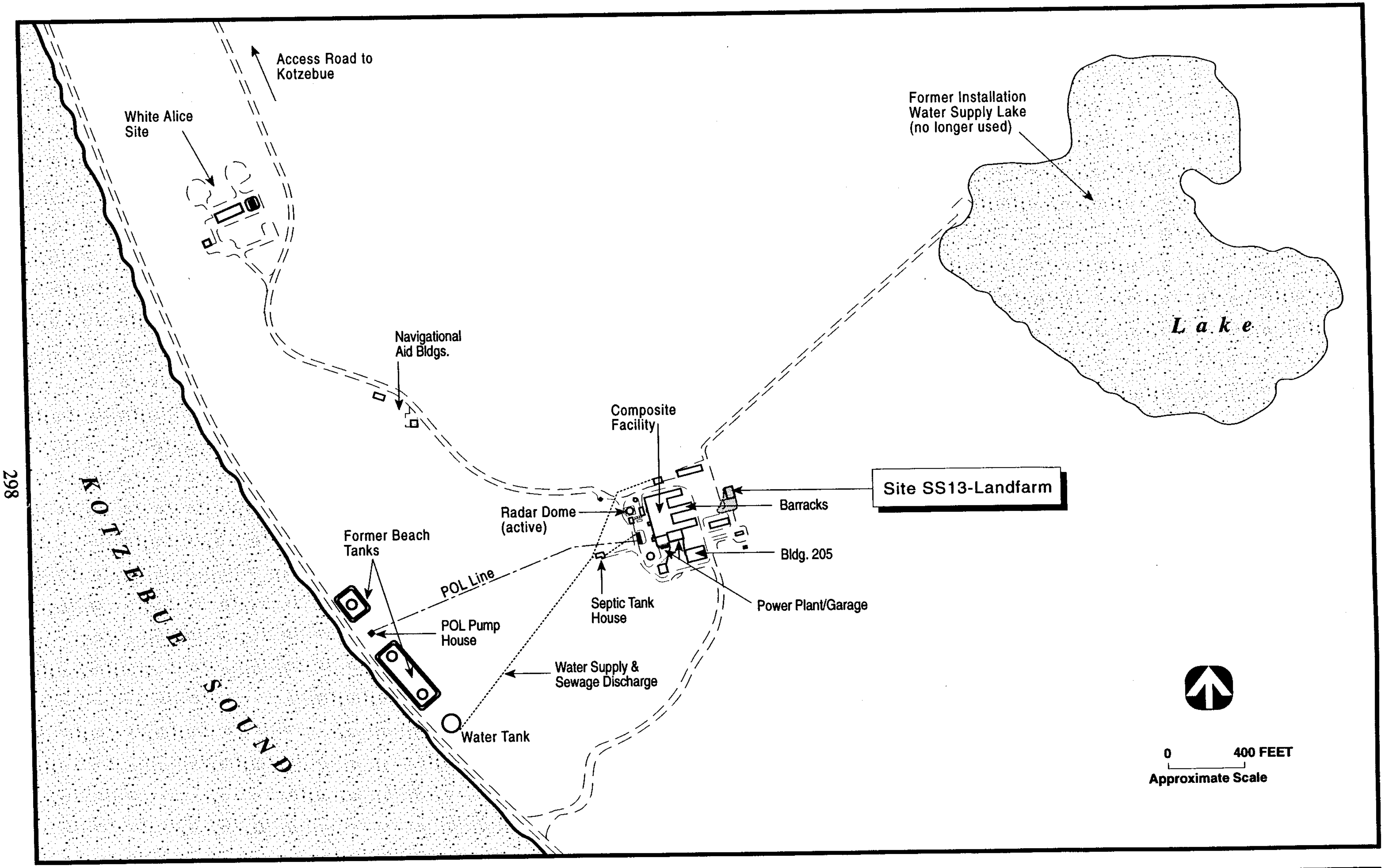


Figure 7-25. Location of Site SS13-Landfarm (AOC1), Kotzebue LRRS, Alaska.

(see Figure 7-25). Surface drainage is to the east-northeast, and small areas of ponded water exist along local drainage pathways.

7.13.3 IRP Investigation Summary

Table 7-13 provides a summary of IRP activities conducted at Site SS13. In 1989, a landfarm was constructed during the Stage 2 RI/FS to remediate petroleum hydrocarbon contaminated soil at Kotzebue LRRS (USAF 1990b). The site was constructed on a level pad (part concrete and part fill) located east of the Composite Facility (see Figure 7-25). Petroleum hydrocarbon contaminated soil and fill were excavated from Site SS01-Waste Accumulation Area No. 1 (approximately 50 cubic yards), Site SS12-Spill No. 2 (approximately 100 cubic yards), and Site SS12-Spill No. 3 (approximately 350 cubic yards), and were stockpiled on 6 mil plastic within the landfarm area. Soil was spread to an approximate thickness of 1.5 feet, and emulsification (Toxigon^{TM}) and micronutrient (Medina^{TM}) agents were applied. The landfarm was mixed weekly over the course of two field seasons (1989-1990) to promote microbial activity, and was subsequently sampled over the course of the two field seasons on an intermittent basis to evaluate reduction in petroleum hydrocarbon levels (USAF 1990b).

A mean reduction in petroleum hydrocarbon contamination was measured during landfarming activities conducted during the 1989-1990 Stage 2 RI/FS (see Section 3.3, Stage 2 RI/FS; Table 3-6). The reduction was probably the result of biological degradation, volatilization, and leaching processes (USAF 1990b). Of these, biodegradation was the most important factor. Volatilization was not considered a significant loss mechanism because: 1) volatile components would likely have dissipated from the spill prior to the study; 2) the volatile components of arctic diesel fuel represent approximately 30 percent (by weight) of the total mixture; 3) relatively cold temperatures and high soil moisture contents were noted during the study; and 4) insufficient aromatic hydrocarbon detections were obtained during the initial site investigation (USAF 1990b). Leaching was also reportedly not an important loss mechanism, because: 1) construction of a berm around the landfarm reduced surface run-off potential; 2) a majority of organic components in diesel fuel are hydrophobic; and 3) soils were subject to many years of precipitation and leaching prior to the study (USAF 1990b). Due to the measured reduction in mean petroleum hydrocarbon concentrations, it was recommended that landfarming activities be continued at Kotzebue LRRS. However, due to loss of project funding, no further active landfarming efforts have been conducted at the site since the 1990 field program.

TABLE 7-13. SUMMARY OF IRP ACTIVITIES CONDUCTED AT SITE SS13-LANDFARM, KOTZEBUE LRRS, ALASKA

Field Sampling	Analyses Performed	Field Activities
1989 Stage 2 RI/FS		
27 Soil Samples	Petroleum Hydrocarbons (EPA Method E 418.1)	■ Emulsification and micronutrients applied to landfarm soil ■ Landfarm soil mixed weekly
1990 Stage 2 RI/FS		
20 Soil Samples	Petroleum Hydrocarbons (EPA Method E 418.1)	■ Emulsification and micronutrients applied to landfarm soil ■ Landfarm soil mixed weekly
1994 Remedial Investigation		
13 Soil Samples	(13) Diesel Range Organics (Method AK102) (1) Residual Range Organics (Method AK102-Extended) (3) Volatile Organic Compounds (EPA Method SW 8260) (3) Semivolatile Organic Compounds (EPA Method SW 8270) (3) Pesticides and PCBs (EPA Method SW 8081) (2) Metals (EPA Method 6010 Series)	■ All sample locations were surveyed
1 Surface Water Sample	Diesel Range Organics (Method AK102) Volatile Organic Compounds (EPA Method SW 8260)	

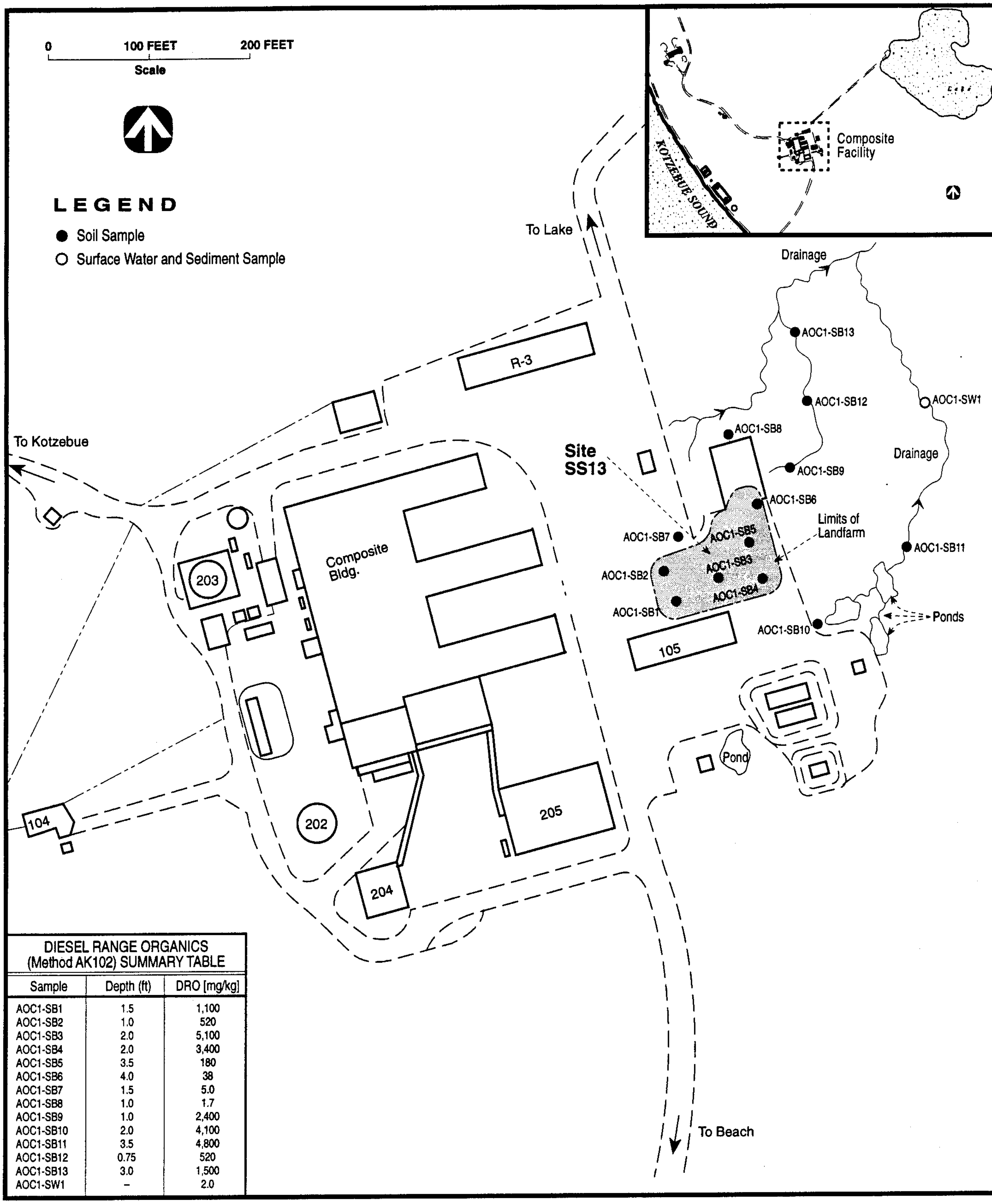
In 1992, ADEC reported concerns to the USAF regarding the landfarm area at Kotzebue LRRS, stating that the cover on the landfarm was torn and in poor condition, and that seepage was identified adjacent to the landfarm (ADEC 1992). ADEC requested that the USAF report on the condition of the landfarm and provide specific landfarm design plans. ADEC recommended landfarming activities begin early in the summer season to maximize remediation efficiency.

During a 1993 site survey, the landfarm was inspected and found to be in relatively poor condition, with no cover or liner to prevent infiltration or runoff and no limitation to site access. Landfarm soil was manually exposed during the site survey, revealing visual and olfactory indications of petroleum hydrocarbon contamination. Additionally, the formerly bermed margin of the landfarm was not discernable from the landfarm material proper. Due to a lack of maintenance and the potential for contaminant migration from the site, the landfarm was identified as an area of concern (AOC1) for investigation during the 1994 RI.

The 1994 RI included an initial inspection of the landfarm to evaluate the condition of the landfarm cell, characterization of current soil conditions, and an evaluation of the surrounding area to determine the potential extent of contamination due to seepage or runoff from the landfarm. The inspection of the landfarm revealed the same conditions identified during the 1993 site survey. Six discrete shallow subsoil samples from within the landfarm cell were collected for analysis (see Table 7-13). In addition to landfarm soil, four shallow subsoil samples were collected from the perimeter of the landfarm. Based on elevated petroleum hydrocarbon concentrations, an additional three shallow subsoil samples were collected and submitted for analysis of diesel range organics. Based on preliminary diesel range organics results in soil, a surface water sample was collected along an extended drainage pathway leading from the site (see Table 7-13). Figure 7-26 provides 1994 RI sample locations at Site SS13. A summary of maximum detected concentrations identified at Site SS13 is provided in Section 4.5, Summary of Analytical Results; Tables 4-12 through 4-21. All sample analytical results for the 1994 RI are provided in Appendix L. All sample station locations were surveyed for horizontal and vertical coordinates (see Appendix C).

7.13.4 Remaining Site Concerns

State and federal ARARs established to guide the 1994 RI are discussed in Section 4.2, Applicable or Relevant and Appropriate Requirements. Petroleum hydrocarbon contamination detected in soil and surface water is the primary environmental concern at Site SS13.



DIESEL RANGE ORGANICS (Method AK102) SUMMARY TABLE

Sample	Depth (ft)	DRO [mg/kg]
AOC1-SB1	1.5	1,100
AOC1-SB2	1.0	520
AOC1-SB3	2.0	5,100
AOC1-SB4	2.0	3,400
AOC1-SB5	3.5	180
AOC1-SB6	4.0	38
AOC1-SB7	1.5	5.0
AOC1-SB8	1.0	1.7
AOC1-SB9	1.0	2,400
AOC1-SB10	2.0	4,100
AOC1-SB11	3.5	4,800
AOC1-SB12	0.75	520
AOC1-SB13	3.0	1,500
AOC1-SW1	-	2.0

Figure 7-26. Location of Sample Stations at Site SS13-Landfarm (AOC1), 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

7.13.4.1 Soils. During the 1994 RI, three of six soil samples collected from within the landfarm cell revealed diesel range organics concentrations above the 1,000 mg/kg ADEC target level for soil at Kotzebue LRRS, including a maximum concentration of 5,100 mg/kg detected in sample AOC1-SB3 (see Figure 7-26). Three soil samples collected downgradient of the site in native tundra revealed elevated diesel range organics concentrations, including Sample AOC1-SB9/12 at 2,400 mg/kg, AOC1-SB10 at 4,100 mg/kg, and AOC1-SB11 at 4,800 mg/kg. Samples AOC1-SB1 and AOC1-SB3 were selected to evaluate residual range organics concentrations and assess if other source(s) of petroleum contamination (e.g., waste oils) exist within the landfarm. Extractions from original AK102 analyses were reanalyzed (within method-specific holding times) using an extended AK102 method to quantify petroleum hydrocarbons detected between C28 to C40. Results indicate residual range concentrations in both samples are well below the ADEC soil target level. No signs of dead vegetation were noted during inspection of the site. In support of the 1994 remedial investigation, a baseline risk assessment was conducted. The ecological risk assessment indicates a potential risk (i.e., $HQ > 1$) for the dietary pathway based on the detection of xylene in Sample AOC1-SB10 at 28 mg/kg ($HQ = 2.83$) and the detection of 2-methylnaphthalene in Sample AOC1-SB2 at 11 mg/kg ($HQ = 2.23$). The ecological based threshold concentration (i.e., soil concentration $HQ \leq 1$) estimated for total xylenes is 2.56 mg/kg, and for 2-methylnaphthalene is 6.61 mg/kg (USAF 1995b). The baseline risk assessment indicates a potential risk to human health (i.e., $> 10^{-6}$ risk) for soil ingestion (1.99E-6) and inhalation of airborne dust (2.14E-6) pathways based on the detection of arsenic in Samples AOC1-SB2 at 9 mg/kg, SB4 at 8 mg/kg, SB7 at 8 mg/kg, and SB10 at 7 mg/kg. Although site soil samples exceed health based threshold criteria for arsenic (i.e., 4.74 mg/kg for ingestion and 4.61 mg/kg for inhalation), their concentrations are less than the arithmetic mean concentration of arsenic measured in background soil samples (i.e., 27 mg/kg). No known sources of arsenic are identified for Site SS13 and the detection of arsenic in background locations indicate this element is naturally occurring. The average concentration of arsenic in natural soils is reportedly 5 mg/kg, but can range from 1 mg/kg to 50 mg/kg (EPA 1983).

7.13.4.2 Surface Water. Diesel range organics at 2.0 mg/L were detected in surface water Sample AOC1-SW1, exceeding the 0.015 mg/L ADEC Water Quality Criteria for petroleum hydrocarbons in surface water (ADEC 1995). No sheen was observed on the water surface at the time of sample collection. No volatile organic compounds were detected in Sample AOC1-SW1. No unacceptable ecological or human health risks were estimated for surface water at Site SS13 based on the 1994 RI results.

7.13.5 Site Recommendations

Soil within the landfarm currently exhibits elevated petroleum hydrocarbon concentrations. It is suspected that infiltration and runoff from the site has impacted native vegetation immediately downgradient (east) of the site. To mitigate further impacts to native tundra, it is recommended that contaminated landfarm soils and fill material be excavated and removed from Site SS13. Onsite treatment of contaminated fill materials is recommended to reduce petroleum hydrocarbon concentrations to acceptable levels for the onsite disposal of treated soil. The estimated volume of 1,528 cubic yards of contaminated materials at or above the 1,000 mg/kg (ADEC soil target level are located in an area 150 feet by 110 feet, with an average depth of 2.5 feet (Figure 7-27). The estimated volume of contaminated soil remaining in the landfarm is significantly larger than the 500 cubic yards of material reportedly stockpiled at the site (see Figure 7-27). The increased volume estimate is due (in part) to the bermed margins of the landfarm not being discernable from the contaminated materials stockpiled within.

Limited action is recommended for native soils impacted at the site, including natural attenuation and long-term monitoring to evaluate natural restoration once source materials have been removed from the site. The natural attenuation and long-term monitoring alternative represents a non-invasive, non-destructive alternative to material removal actions or other approaches that would negatively impact the fragile tundra environment and local ecosystem. Biannual monitoring is recommended for native tundra impacted at Site SS13, including visual inspection and photographs to document site conditions once suspected source materials have been removed. Monitoring should incorporate limited surface water and/or soil sample collection for diesel range organics to evaluate the effectiveness of the natural attenuation alternative. Surface water sample(s) should be collected from ponded site water previously characterized during the 1994 RI to assure appropriate comparison of DRO concentrations between monitoring events. Similarly, soil sample(s) should be collected from previous sample locations (in tundra) which revealed elevated DRO concentrations. Data obtained from biannual monitoring should be evaluated to determine the effectiveness of natural attenuation and assess the need and/or requirements for subsequent monitoring of Site SS13.

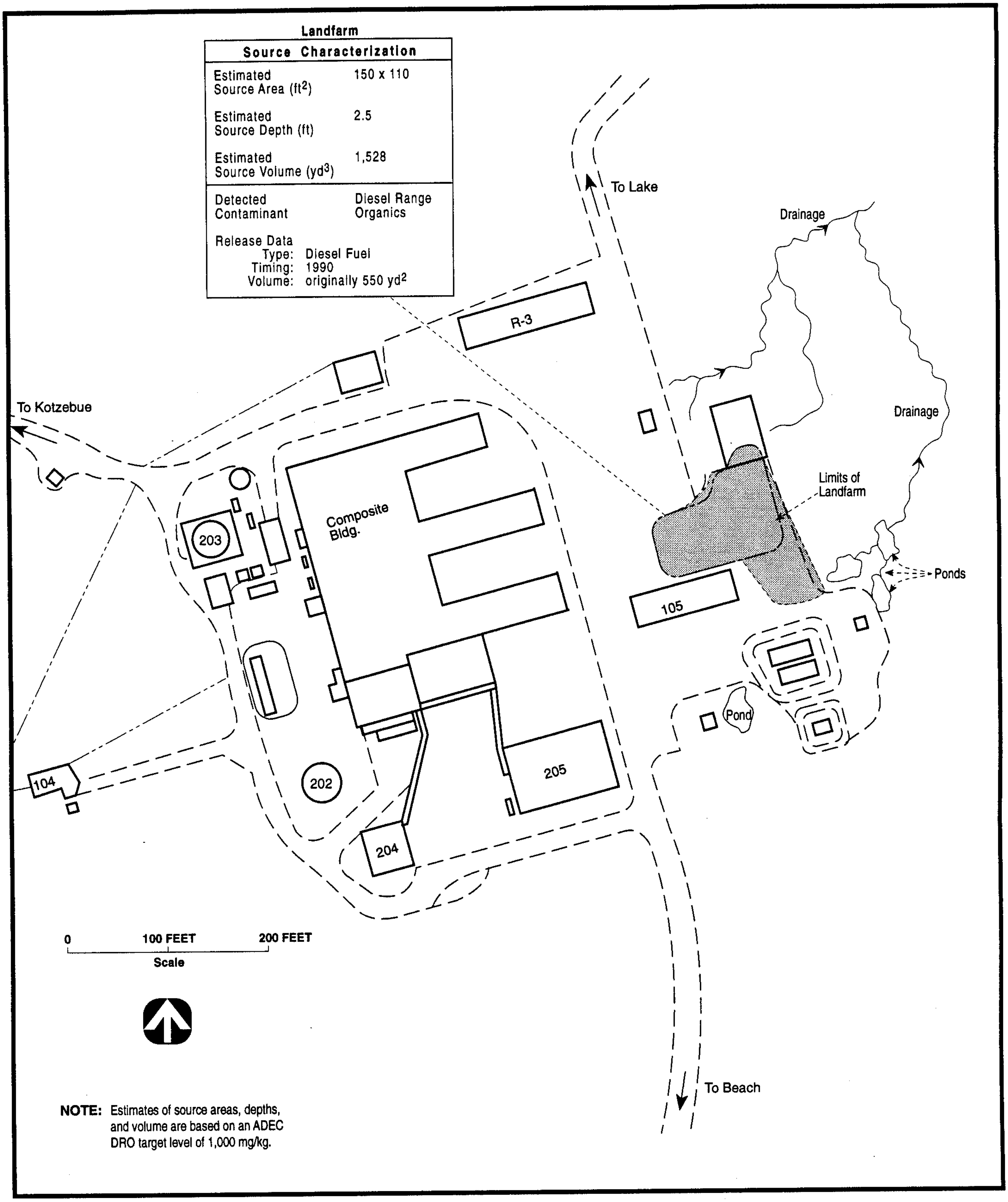


Figure 7-27. DRO Contaminant Source Characterization for Site SS13-Landfarm (AOC1), 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

7.14 SITE SS14-EAST TANKS (AOC3)

7.14.1 Summary of Site Status

Site SS14-East Tanks (AOC3) is the location of two large (approximately 20,000 gallons each), empty above-ground diesel fuel storage tanks, located on the east side of the access road east of the Composite Facility. Petroleum hydrocarbons detected in soil (up to 10,000 mg/kg) are the primary environmental concern at Site SS14. Elevated petroleum hydrocarbon concentrations in gravel fill materials at Site SS14 provide a potential source of contamination to nearby native vegetation. It is recommended that contaminated fill material exceeding the ADEC soil target level of 1,000 mg/kg be excavated and removed from the site. Onsite treatment of contaminated fill materials is recommended to reduce petroleum hydrocarbon concentrations to levels acceptable for onsite disposal of treated soil.

7.14.2 Site Description

Site SS14 is the site of three empty above-ground diesel fuel storage tanks located on the east side of the access road, east of the Composite Facility (Figure 7-28). The two large above-ground mogas fuel tanks have an estimated capacity of 20,000 gallons each, are supported on concrete footings set in a gravel pad, and are contained within a bermed area. A single small (estimated capacity approximately 3,000 gal), empty above-ground diesel fuel storage tank is located immediately south of the larger tanks at Site SS14.

The two large above-ground fuel tanks are situated on a raised gravel pad approximately four to five feet thick and at an approximate elevation of 145 feet above sea level. Surface drainage from the gravel pad supporting the above-ground fuel tanks is primarily to the northeast, toward the former water supply lake located approximately 0.5 mile away. Surface water at the site is limited to small areas of ponded water. Permafrost was encountered at approximately 3 feet below ground surface at the base of the gravel pad.

7.14.3 IRP Investigation Summary

A site survey of Kotzebue LRRS was conducted in 1993 to evaluate current site conditions, identify potential areas of concern, and obtain information necessary to prepare RI/FS scoping documents for the 1994 IRP field activities. During the site survey, some signs of soil staining directly beneath outlet valves were observed. Since the tanks and surrounding area at Site SS14 had not been assessed during previous

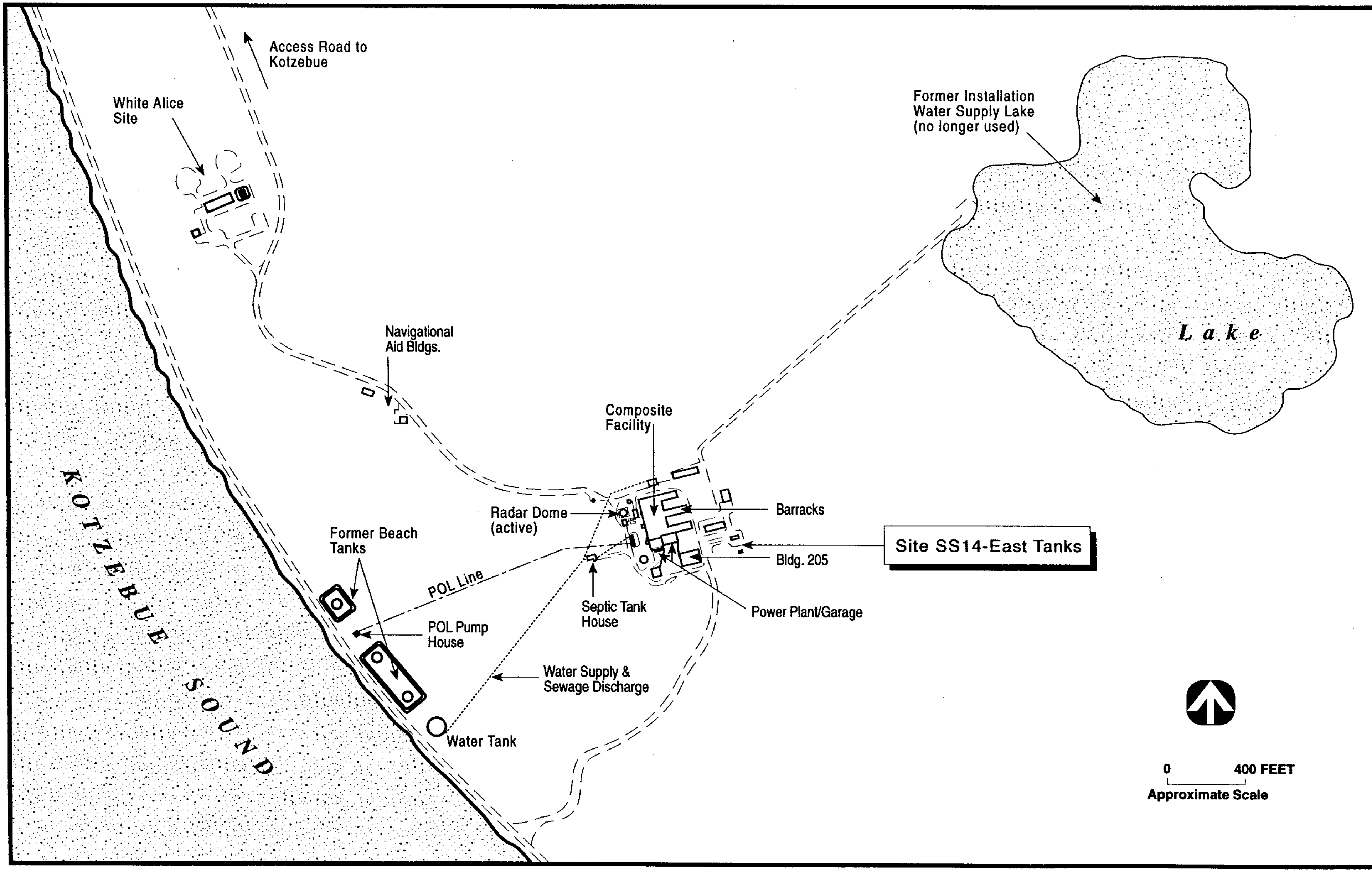


Figure 7-28. Location of Site SS14-East Tanks (AOC3), Kotzebue LRRS, Alaska.

investigations the site was identified as an area of concern (AOC3) for investigation during the 1994 RI. It was later designated Site SS14.

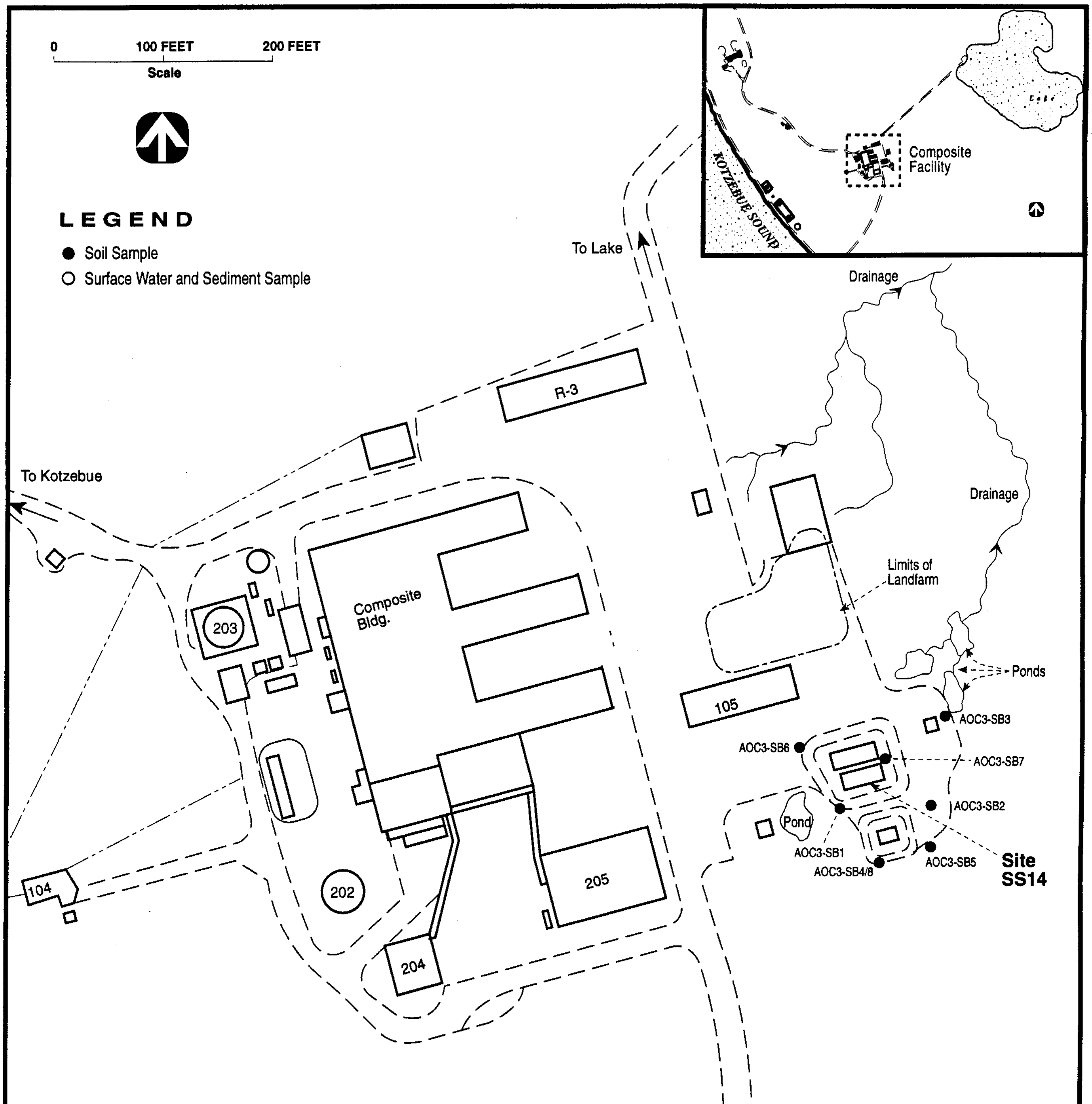
Figure 7-29 provides the 1994 sample locations at Site SS14. Site SS14 was characterized during the 1994 RI by collecting a total of seven shallow subsoil samples for diesel range organics (Method AK102) analysis. In addition, three shallow subsoil samples were submitted for analysis of gasoline range organics (Method AK101), volatile organic compounds (EPA Method SW8260), semivolatile compounds (EPA Method SW 8270), and pesticides and PCBs (EPA Method SW8081). A summary of maximum detected concentrations identified at Site SS14 is provided in Section 4.5, Summary of Analytical Results; Tables 4-12 through 4-21. All sample analytical results for the 1994 RI are provided in Appendix K. All sample station locations were surveyed for horizontal and vertical coordinates (see Appendix C).

7.14.4 Remaining Site Concerns

State and federal ARARs established to guide the 1994 RI are discussed in Section 4.2, Applicable or Relevant and Appropriate Requirements. Petroleum hydrocarbons detected in soil are the primary environmental concern at Site SS14. Three of seven soil samples revealed diesel range organics concentrations above the 1,000 mg/kg ADEC target level for soil, with a maximum concentration of 10,000 mg/kg in Sample AOC3-SB7. Gasoline range organics were detected at 740 mg/kg in Sample AOC3-SB5 and at 4,700 mg/kg in Sample AOC3-SB7 (see Figure 7-29). No signs of dead or stressed vegetation adjacent to the site were noted during the site inspection. No unacceptable ecological or human health risks were identified for soil at Site SS14 based on the 1994 RI results.

7.14.5 Site Recommendations

Elevated petroleum hydrocarbon concentrations in gravel fill materials at Site SS14 provide a potential source of contamination to nearby native vegetation. It is recommended that contaminated fill material exceeding the ADEC soil target level of 1,000 mg/kg be excavated and removed from the site. Onsite treatment of contaminated fill materials is recommended to reduce petroleum hydrocarbon concentrations to levels acceptable for onsite disposal of treated soil. The estimated 1,037 cubic yards of contaminated material at or above the 1,000 mg/kg ADEC soil target level are located in an area 100 feet by 70 feet, with an average estimated depth of 3 feet (Figure 7-30).



DIESEL RANGE ORGANICS (Method AK102) SUMMARY TABLE		
Sample	Depth (ft)	DRO [mg/kg]
AOC3-SB1	1.5	22
AOC3-SB2	1.5	5,400
AOC3-SB3	3.0	1,000
AOC3-SB4/8	2.5	3.5
AOC3-SB5	2.0	300
AOC3-SB6	2.5	130
AOC3-SB7	2.0	10,000

GASOLINE RANGE ORGANICS (Method AK101) SUMMARY TABLE		
Sample	Depth (ft)	GRO [mg/kg]
AOC3-SB5	2.0	740
AOC3-SB6	2.5	17
AOC3-SB7	2.0	4,700

Figure 7-29. Location of Sample Stations at Site SS14-East Tanks (AOC3), 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

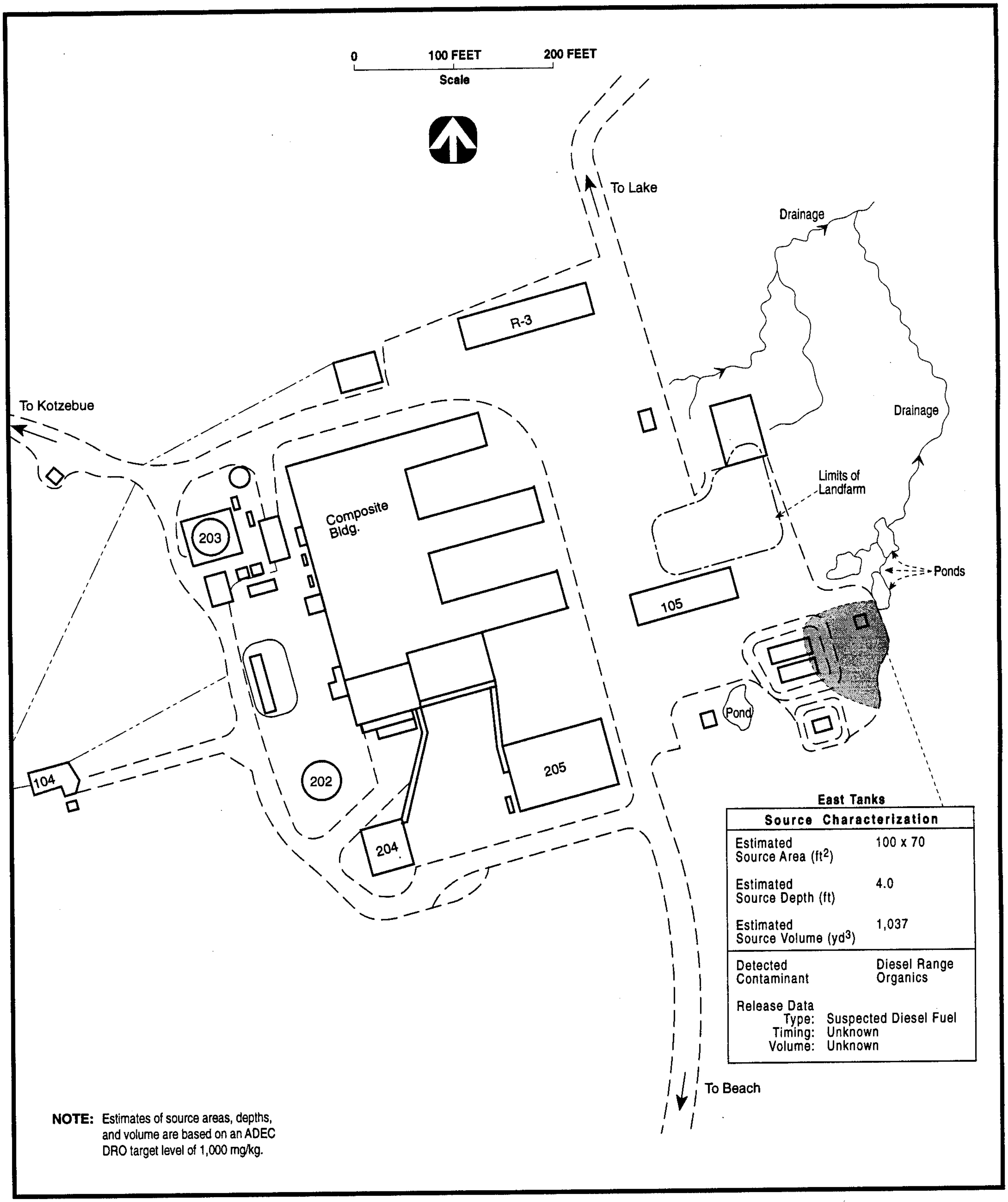


Figure 7-30. DRO Contaminant Source Characterization for Site SS14-East Tanks (AOC3), 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

7.15 SITE SS15-GARAGE/POWER PLANT (AOC4)

7.15.1 Summary of Site Status

Site SS15-Garage/Power Plant (AOC4) is the location of the garage and power plant located at the Composite Facility at Kotzebue LRRS. Petroleum hydrocarbons in gravel fill (up to 10,000 mg/kg) are the primary environmental concern at the site. Petroleum hydrocarbon contamination identified in gravel fill materials at Site SS15 has commingled with contaminated fill associated with Site SS12-Spills No. 2 and 3; therefore, it is probable that final remediation of Site SS15 can be incorporated with Site SS12 as contamination is similar in nature. It is recommended that contaminated fill material exceeding the ADEC soil target level of 1,000 mg/kg be excavated and removed from the site. Onsite treatment of contaminated fill materials is recommended to reduce petroleum hydrocarbon concentrations to levels acceptable for onsite disposal of treated soil.

7.15.2 Site Description

Site SS15 is the location of the garage and power plant associated with the Composite Facility at Kotzebue LRRS (Figure 7-31). The power plant formerly supplied electricity for the facility through the use of 10 large diesel-powered generators. The garage area was the vehicle maintenance center for the facility; however, past waste disposal practices associated with the garage area are not known.

The gravel pad underlying Site SS15 varies in thickness from approximately 2.5 feet beneath the raised flooring of the power plant, to approximately 7 feet thick immediately south of the power plant. Frozen ground was encountered beneath the power plant as shallow as 1 foot below ground surface. Surface drainage from Site SS15 is considered poor, with a suspected direction to the west to southwest (see Figure 7-31).

7.15.3 IRP Investigation Summary

A site survey of Kotzebue LRRS was conducted in 1993 to evaluate current site conditions, identify potential areas of concern, and obtain information necessary to prepare RI/FS scoping for the 1994 IRP field activities. During the site survey, stained soils were observed beneath the raised flooring of the power plant and garage area (see Figure 7-31). No previous characterization of soil associated with the power plant or garage area had been conducted; therefore, both the power plant and garage were identified as an area of concern (AOC4) for investigation during the 1994 RI. Later the site was designated

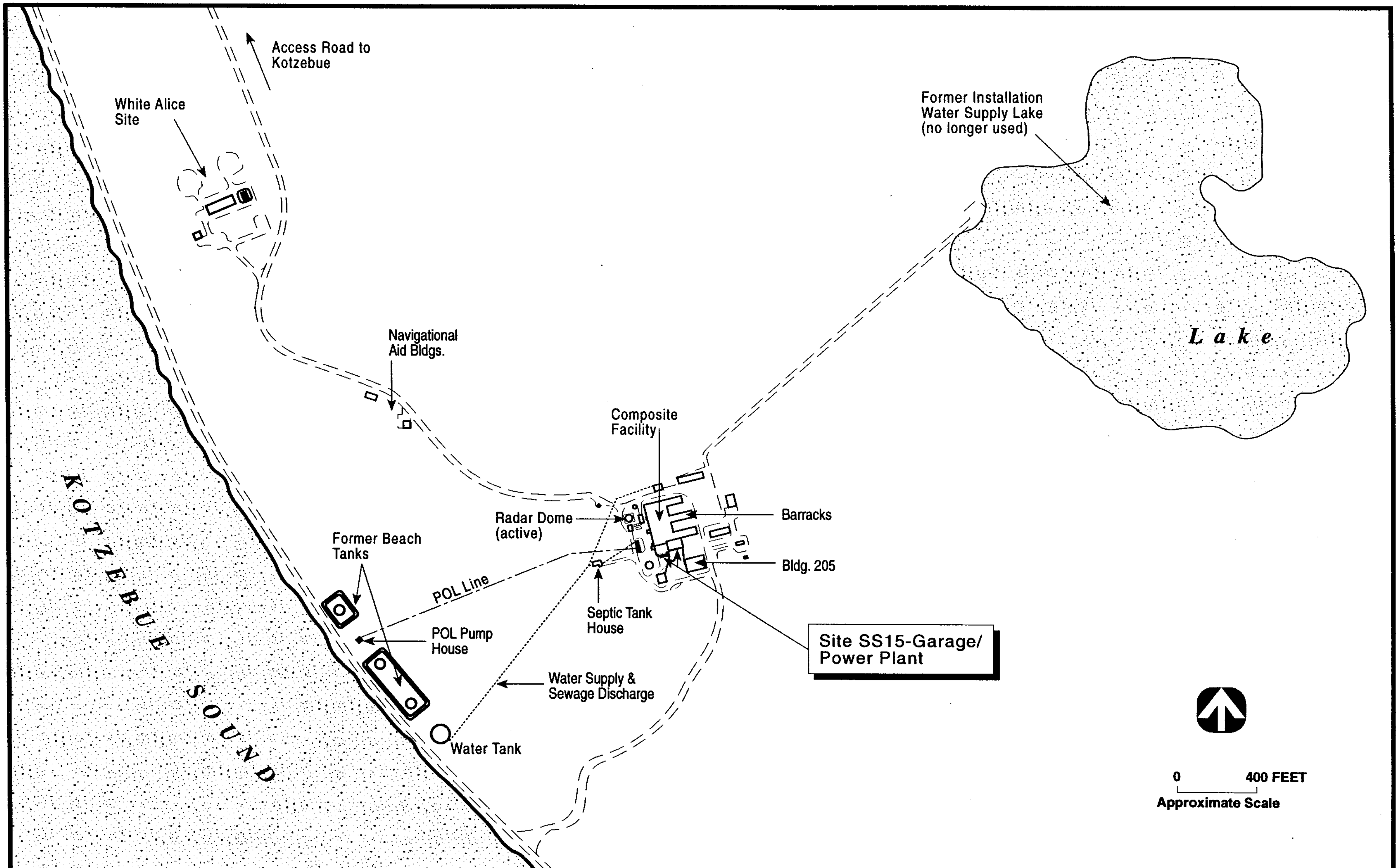


Figure 7-31. Location of Site SS15-Garage/Power Plant (AOC4), Kotzebue LRRS, Alaska.

Site SS15. During the 1994 RI, site characterization included a facility inspection of the power plant and garage and surrounding area, and shallow subsoil sampling.

7.15.3.1 Power Plant and Garage Inspection. On 20 June 1994, an inspection was conducted of the interior of the power plant and garage structures to identify past operations potentially involving the use of hazardous materials. The inspection included a survey to locate any floor drains that could provide a pathway for hazardous substances to impact soil beneath the structures.

The power plant contains 10 large diesel-powered generators, formerly used to supply electricity for the facility. Fuel was provided to these generators from storage tanks located west of the power plant through a system of piping contained within a subfloor chamber. A strong fuel odor was noted in the power plant and fuel staining was present at several locations in the subfloor chamber. A survey conducted beneath the power plant indicated the presence of fuel staining on the underside of the subfloor chamber containing the piping. Distinct soil staining and a strong petroleum odor were observed in the gravel fill located underneath and to the south of the power plant.

The garage, located adjacent to the power plant, contained a sink and four floor drains. The garage housed three 55-gallon drums containing what appeared to be waste oil. No evidence of leakage from these drums was observed during the building inspection. A sewer line that collected discharges from the sink and floor drains was inspected. The sewer line is exposed above ground for its entire length, except where it crosses under the access road (gravel fill) at the western boundary of the Composite Facility. Waste entering the sewer line from within the garage flows north where it connects to the main sewer line of the composite building, approximately 70 feet north of the garage. The main sewer line travels west under the Composite Facility and discharges into the septic building (see Figure 7-31). No breaks or signs of past leaking of the sewer lines were observed upstream of the septic building; therefore, no soil samples were collected along these sections of the sewer piping.

7.15.3.2 Site Sampling. During the 1994 RI, a total of four shallow subsoil samples (AOC4-SB2, SB3, SB4, and SB5), and one deeper soil boring (AOC4-SB1) to 7 feet below ground surface, were collected during the initial characterization of Site SS15 (Table 7-14). Based on the preliminary diesel range organics results, two additional shallow subsoil samples (AOC4-SB6 and SB8), and one additional soil boring (AOC4-SB7) to 6.3 feet below ground surface, were collected and analyzed for diesel range

TABLE 7-14. 1994 REMEDIAL INVESTIGATION ACTIVITIES SUMMARY FOR SITE SS15, KOTZEBUE LRRS, ALASKA

Field Sampling	Analyses Performed		Field Activities
8 Soil Samples	(8)	Diesel range organics (Method AK 102)	■ Power Plant and Garage were inspected
	(5)	Gasoline range organics (Method AK 101)	
	(1)	Residual range organics (Method AK 102-Extended)	■ All sample locations were surveyed
	(5)	Volatile organic compounds (EPA Method SW 8260)	
	(5)	Semivolatile compounds (EPA Method SW 8270)	
	(5)	Pesticides and PCBs (EPA Method SW 8081)	
	(3)	Metals (EPA Method 6010 Series)	

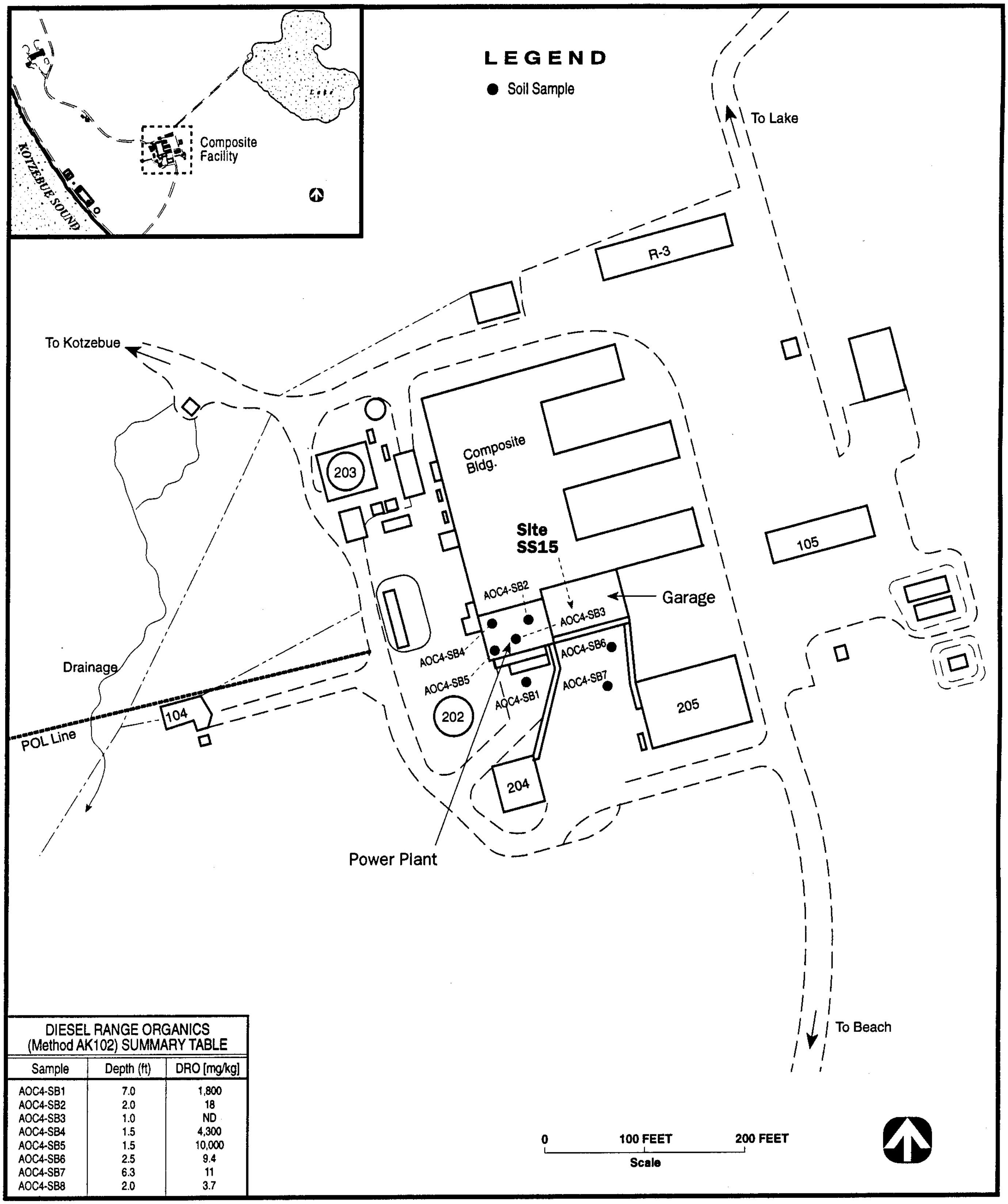
organics to provide a more comprehensive petroleum hydrocarbon characterization of the site. A summary of maximum detected concentrations identified at Site SS15 is provided in Section 4.5, Summary of Analytical Results; Tables 4-12 through 4-21. All sample analytical results for the 1994 RI are provided in Appendix L. All sample station locations were surveyed for horizontal and vertical coordinates (see Appendix C).

A single subsoil sample (AOC4-GT5-F2) was collected from engineered fill material for analysis of geotechnical parameters, including permeability (ASTM MEthod D5084) and grain size distribution (ASTM Methods C136 and D442), and for total organic carbon (EPA Method 9060). Geotechnical sample results are discussed in Section 4.6.4, Geotechnical Sample Results, and are provided in Appendix E.

7.15.4 Remaining Site Concerns

State and federal ARARs established to guide the 1994 RI are discussed in Section 4.2, Applicable or Relevant and Appropriate Requirements. The primary environmental concern at Site SS15 is petroleum hydrocarbon contamination detected in gravel fill. Three of eight soil samples, including Samples AOC4-SB1, SB4, and SB5, revealed concentrations of diesel range organics above the 1,000 mg/kg ADEC soil target level. Sample AOC4-SB5 provided the maximum diesel range organic concentration at 10,000 mg/kg (see Figure 7-32). Elevated gasoline range organics were identified in two samples (AOC 4-SB4 and SB5), at 950 mg/kg each. Sample AOC4-SB5 was selected to evaluate residual range organics concentration and assess other potential source(s) of petroleum contamination (e.g., waste oils). The extraction from the original AK102 analysis was reanalyzed (within method-specific holding times) using an extended AK102 method to quantify residual range organics between C28 and C40. Results indicate a match for motor oil at a reported concentration of 1,100 mg/kg.

In support of the 1994 remedial investigation, a baseline risk assessment was conducted which indicates no unacceptable ecological risks identified for soils at Site SS15 based on 1994 RI results. The health risk assessment indicated a potential risk (i.e., $> 10^{-6}$ risk) to human health for soil ingestion (1.66E-6) and inhalation of airborne dust (2.14E-6) pathways based on the detection of arsenic in Samples AOC4-SB2 at 7 mg/kg and AOC4-SB4 at 8 mg/kg. Both Sample AOC4-SB2 and SB4 are located under the power plant structure at the site (see Figure 7-32) and therefore limit potential exposure by either pathway. Although site soil samples exceed health based threshold criteria for arsenic (i.e., 4.74 mg/kg



DIESEL RANGE ORGANICS (Method AK102) SUMMARY TABLE

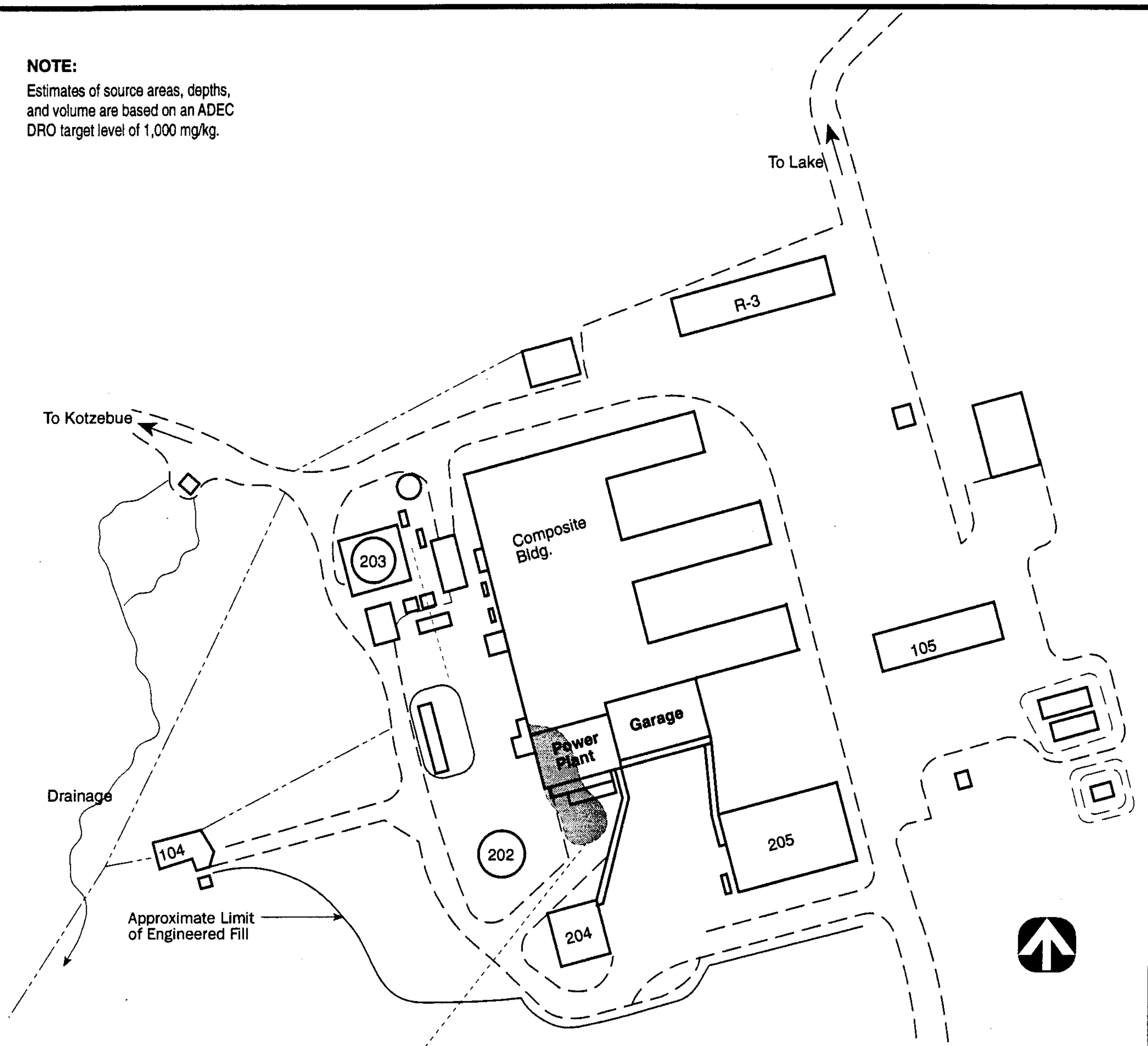
Sample	Depth (ft)	DRO [mg/kg]
AOC4-SB1	7.0	1,800
AOC4-SB2	2.0	18
AOC4-SB3	1.0	ND
AOC4-SB4	1.5	4,300
AOC4-SB5	1.5	10,000
AOC4-SB6	2.5	9.4
AOC4-SB7	6.3	11
AOC4-SB8	2.0	3.7

Figure 7-32. Location of Sample Stations at Site SS15-Garage/Power Plant (AOC4), 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

for ingestion and 4.61 mg/kg for inhalation), their concentrations are less than the arithmetic mean concentration for arsenic measured in background soil samples (i.e., 27 mg/kg). No known sources of arsenic are identified for Site SS13 and the detection of arsenic in background locations indicate this element is naturally occurring. The average concentration of arsenic in natural soils is reportedly 5 mg/kg, but can range from 1 mg/kg to 50 mg/kg (EPA 1983).

7.15.5 Site Recommendations

Petroleum hydrocarbon contamination identified in gravel fill materials at Site SS15 has commingled with contaminated fill associated with Site SS12 Spills No. 2 and 3; therefore, it is probable that final remediation of Site SS15 can be incorporated with Site SS12 as contaminated fill materials are of similar nature. As recommended at Site SS12, contaminated fill material exceeding the ADEC soil target level of 1,000 mg/kg should be excavated and removed from the site. Onsite treatment of contaminated fill materials is recommended to reduce petroleum hydrocarbon concentrations to levels acceptable for onsite disposal of treated soil. The estimated 334 cubic yards of contaminated materials at or above the 1,000 mg/kg ADEC soil target level are located in an area 100 feet by 30 feet, with an estimated average depth of 3 feet (Figure 7-33).



Garage/Power Plant

Source Characterization	
Estimated Source Area (ft^2)	100 x 30
Estimated Source Depth (ft)	3.0 avg.
Estimated Source Volume (yd^3)	334 .
Detected Contaminant	Diesel Range Organics
Release Data	
Type:	Suspected Diesel Fuel
Timing:	Unknown
Volume:	Unknown

Figure 7-33. DRO Contaminant Source Characterization at Site SS15-Garage/Power Plan (AOC4), 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

7.16 SITE SS16-NAVIGATIONAL AID BUILDINGS (AOC6)

7.16.1 Summary of Site Status

Site SS16-Navigational Aid Buildings (AOC6) is the vicinity of the Navigational Aid Buildings (Buildings 101 and 102) and surrounding area located between the Composite Facility and the White Alice Site at Kotzebue LRRS. Petroleum hydrocarbons detected in gravels (up to 25,000 mg/kg) and surface water (estimated at 0.11 mg/L) are the primary environmental concern at Site SS16. Petroleum hydrocarbon concentrations in gravel fill materials at Site SS16 provide a potential source of contamination to nearby native vegetation and surface (ponded) water. To mitigate potential impacts to native tundra and the surrounding area, it is recommended that contaminated fill material exceeding the ADEC soil target level of 1,000 mg/kg be excavated and removed from Site SS16. Onsite treatment of contaminated fill materials is recommended to reduce petroleum hydrocarbon concentrations to acceptable levels for the onsite disposal of treated soil.

7.16.2 Site Description

Site SS16 is the vicinity of the Navigational Aid Buildings and surrounding area located between the Composite Facility and the White Alice Site (Figure 7-34). The Navigational Aid Buildings (Buildings 101 and 102) are located approximately 300 feet apart from each other on raised gravel pads, which intersect the access road immediately to the north. A small day tank is located adjacent to Building 101, and a fuel line connecting to both Building 101 and 102 travels southeast toward the Composite Facility through native tundra. The site is located on the crest of the tundra hill, at an approximate elevation of 148 feet above sea level. The Navigational Aid Buildings are separated by areas of ponded water which form in low lying areas in native tundra. Surface drainage at the site is directed to the southwest, where the tundra hill slopes moderately towards Kotzebue Sound (see Figure 7-34).

7.16.3 IRP Investigation Summary

In 1993, a site survey of Kotzebue LRRS was conducted to evaluate current site conditions, identify potential areas of concern, and obtain information necessary to prepare RI/FS scoping documents for the 1994 IRP field activities. During the site survey, limited soil staining was identified at Navigational Aid Building 102. During a 1993 Environmental Site Assessment conducted at Building 101, petroleum hydrocarbons were detected in soil (up to 4,300 mg/kg), adjacent to the small day tank (Shannon and Wilson, Inc. 1993). Due to the detection of diesel range organics in soil, the Navigational Aid Buildings

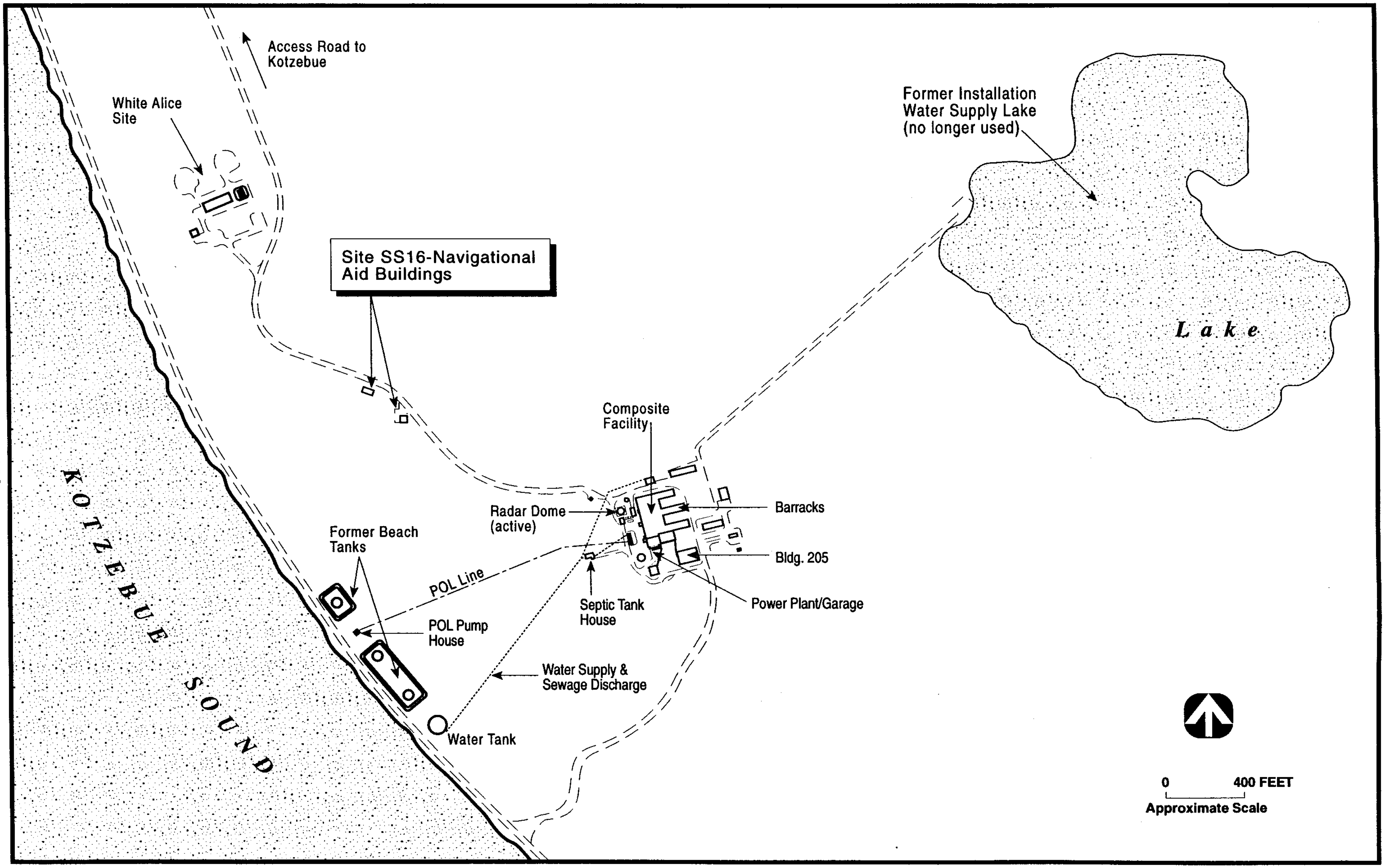


Figure 7-34. Location of Site SS16-Navigational Aid Buildings (AOC6), Kotzebue LRRS, Alaska.

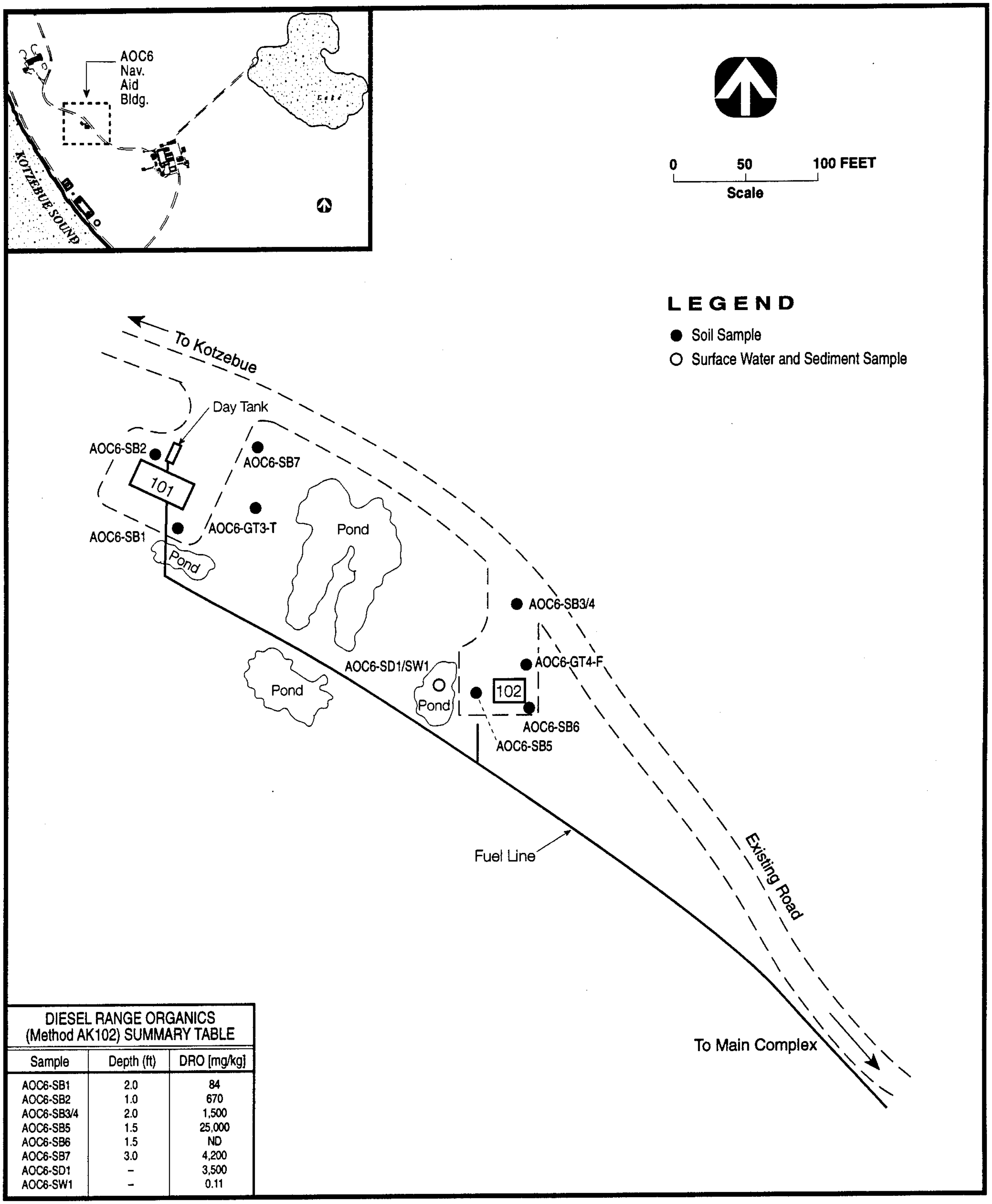
and surrounding area were identified as an area of concern (AOC6) for investigation during the 1994 RI. The site was formally named Site SS16 during the 1994 RI. The 1994 RI included a building inspection, a survey of the surrounding area, and the collection of soil, sediment, and surface water samples at Site SS16.

7.16.3.1 Navigational Aid Buildings (101 and 102) Inspection. On 20 June 1994, structures were inspected for indications of past operations involving the potential use or storage of hazardous materials. Building 101 was posted with a sign indicating that the structure contained experimental equipment belonging to the Geophysical Institute at the University of Alaska. Access to the interior of this building was not available. Inspection of the exterior of this building identified the presence of a small day tank on the north side of the structure (Figure 7-35). The only piping leading into the structure were fuel supply lines from the day tank. Stained soil was not observed under or adjacent to this structure.

Building 102 formerly housed a transformer and backup generator used to power the navigational aid light located on the roof. No operational equipment was present at this location. One large transformer was still located in the building. A label on the transformer indicated it was drained and cleaned in August 1992. This building was also equipped with a day tank used to fuel the backup generator. This day tank, now removed, was located at the southwest corner of the building. A fuel line connected the day tanks at the Navigational Air Buildings 101 and 102 to the fuel distribution system at the main facility (see Figure 7-35). The building does not contain stored chemicals, supplies, or equipment. An area of stained soil was present north of the building near the road and was included in the characterization of the site.

7.16.3.2 Site Sampling. Figure 7-35 provides 1994 RI sample locations at Site SS16. During the 1994 RI, two shallow subsoil samples were collected from locations adjacent to Building 101 (Table 7-15). A third shallow subsoil sample (AOC6-SB7) was collected and submitted for diesel range organics (Method AK102) analysis, based on field screening evidence of petroleum hydrocarbon contamination (see Figure 7-35).

Two subsoil samples were collected for geotechnical parameters, including permeability (ASTM Method D5084) and grain-size distribution (ASTM Methods C136 and D442), and for total organic carbon (EPA Method 9060). Sample AOC6-GT3-T was collected from native tundra and Sample AOC6-GT4-F was



DIESEL RANGE ORGANICS
(Method AK102) SUMMARY TABLE

Sample	Depth (ft)	DRO [mg/kg]
AOC6-SB1	2.0	84
AOC6-SB2	1.0	670
AOC6-SB3/4	2.0	1,500
AOC6-SB5	1.5	25,000
AOC6-SB6	1.5	ND
AOC6-SB7	3.0	4,200
AOC6-SD1	-	3,500
AOC6-SW1	-	0.11

Figure 7-35. Location of Sample Stations at Site SS16-Navigational Aid Buildings (AOC6), 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

TABLE 7-15. 1994 REMEDIAL INVESTIGATION ACTIVITIES SUMMARY
FOR SITE SS16-NAVIGATIONAL AID BUILDINGS, KOTZEBUE LRRS, ALASKA

Field Sampling	Analyses Performed	Field Activities
6 Soil Samples	(6) Diesel Range Organics (Method AK 102) (1) Residual Range Organics (Method AK 102-Extended) (4) Volatile Organic Compounds (EPA Method SW 8260) (4) Semivolatile Organic Compounds (EPA Method SW 8270) (4) Pesticides and PCBs (EPA Method SW 8081) (2) Metals (EPA Method 6010 Series)	■ All sample locations were surveyed.
1 Sediment Sample	Diesel Range Organics (Method AK 102) Volatile Organic Compounds (EPA Method SW 8260) Semivolatile Organic Compounds (EPA Method SW 8270) Pesticides and PCBs (EPA Method SW 8081) Metals (EPA Method 6010 Series)	
1 Surface Water Sample	Diesel Range Organics (Method AK 102) Volatile Organic Compounds (EPA Method SW 8260) Semivolatile Organic Compounds (EPA Method SW 8270) Pesticides and PCBs (EPA Method SW 8081) Metals (EPA Method 6010 Series)	

collected from engineered fill material to estimate critical parameters regarding contaminant transport in these lithologies (see Figure 7-35). Geotechnical sample results are discussed in Section 4.6.4, Geotechnical Sample Results, and are provided in Appendix E.

Site characterization at Building 102 included the collection of three shallow subsoil samples (see Table 7-15). A field decision was made to collect a surface water and sediment sample due to a slight sheen observed on the surface of ponded water which drained the site (see Figure 7-35). The surface water and sediment sample were analyzed for the same parameters chosen to characterize soil. A summary of maximum detected concentrations identified at Site SS16 is provided in Section 4.5, Summary of Analytical Results; Tables 4-12 through 4-21. All sample analytical results for the 1994 RI are provided in Appendix L. All sample station locations were surveyed for horizontal and vertical coordinates (see Appendix C).

7.16.4 Remaining Site Concerns

State and federal ARARs established to guide the 1994 RI are discussed in Section 4.2, Applicable or Relevant and Appropriate Requirements. Petroleum hydrocarbons detected in soil and surface water are the primary environmental concern at Site SS16.

7.16.4.1 Soil/Sediment. One of three soil samples (Sample AOC6-SB7 at 4,200 mg/kg) collected at Building 101 revealed diesel range organics concentrations above the 1,000 mg/kg ADEC target level for soil. During a previous site investigation, a sample located on the east side of the above-ground day tank revealed a concentration of 4,200 mg/kg (see Figure 7-35).

Two of three soil samples collected at Building 102 revealed diesel range organics concentrations above the 1,000 mg/kg ADEC target level for soil, including Samples AOC6-SB3 at 1,500 mg/kg and AOC6-SB5 at 25,000 mg/kg (see Figure 7-35). Sample AOC6-SB3 and Sample AOC6-SB5 were selected to evaluate residual range organics concentrations and assess other potential source(s) of petroleum hydrocarbon contamination (e.g., waste oils). Extracts from the original AK102 analyses were reanalyzed (within method-specific holding times) using an extended AK102 method to quantify hydrocarbons between C28 to C40. Residual range organics was detected in Sample AOC6-SB3 at 1,300 mg/kg. However, in the laboratory analyst's opinion, the result was not a match for motor oil. Sample AOC6-SB5 revealed a residual range organics concentration of 830 mg/kg, compared to 25,000 mg/kg detected in

the same sample for diesel range organics. Sediment sample AOC6-SD1 revealed diesel range organics at 3,500 mg/kg.

In support of the 1994 RI, a baseline risk assessment was conducted. No significant ecological risks were identified for soil at Site SS16 based on the 1994 RI results. The health risk assessment indicated a potential risk to human health (i.e., $>10^{-6}$ risk) for the soil ingestion pathway, based on the detection of PCB (Aroclor 1254) in one of five samples (Sample AOC6-SB5) at 0.05 mg/kg (see Figure 7-35). The baseline risk assessment incorporated a number of conservative assumptions, including the frequency at which recreational and subsistence users may be exposed to contaminants (e.g., assumes exposure every day during the four summer months when contact with contaminants is not limited by frozen ground and/or snow cover). Based on the conservative nature of the baseline risk assessment, the limited detection of Aroclor 1254 at the site, and the fact that the concentration of Aroclor 1254 is well below the U.S. EPA Region 10 PCB cleanup criteria established at 10 mg/kg for soil at Kotzebue LRRS (EPA 1987), no remedial action directed at PCBs is recommended. The health risk assessment indicated a potential risk to human health for soil ingestion (2.11E-6) and inhalation of airborne dust (2.14E-6) pathways based on the detection of arsenic in Sample AOC6-SB2 at 6 mg/kg, AOC6-SD1 at 5 mg/kg and AOC6-SB5 at 5 mg/kg. Although site soil samples exceed health based threshold criteria for arsenic (i.e., 4.74 mg/kg for ingestion and 4.61 mg/kg for inhalation), their concentrations are less than the arithmetic mean concentration of arsenic measured in background soil samples (i.e., 27 mg/kg). No known sources of arsenic are identified for Site SS16 and the detection of arsenic in background locations indicate this element is naturally occurring. The average concentration of arsenic in natural soils is reportedly 5 mg/kg, but can range from 1 mg/kg to 50 mg/kg (EPA 1983).

7.16.4.2 Surface Water. Diesel range organics at an estimated concentration of 0.11 mg/L was detected in Sample AOC6-SW1, exceeding the 0.015 mg/L ADEC Water Quality Criteria for petroleum hydrocarbons in surface water (ADEC 1995). A slight sheen was observed on the water surface at the time of sample collection. The baseline risk assessment indicated a potential ecological risk (i.e., hazard quotient >1) for the water intake pathway based on the detection of manganese in Sample AOC6-SW1 at 0.27 mg/L (USAF 1995b). The baseline ecological risk assessment incorporated a number of conservative assumptions, including the assumption for caribou that a given animal would be present in the vicinity of Kotzebue LRRS for 2 months every year. This is a very conservative assumption considering the fact that the animals that have been sighted in the Kotzebue vicinity during recent years have been

migrating and would be likely to remain within the influence of contaminants detected at Kotzebue LRRS for only short periods of time.

7.16.5 Site Recommendations

Petroleum hydrocarbons in gravel fill materials at Site SS16 presents a potential source of contamination to nearby native vegetation and surface (ponded) water. To mitigate potential impacts to native tundra and the surrounding area, it is recommended that contaminated fill material exceeding the ADEC soil target level of 1,000 mg/kg be excavated and removed from Site SS16. Onsite treatment of contaminated fill materials is recommended to reduce petroleum hydrocarbon concentrations to acceptable levels for the onsite disposal of treated soil. The estimated volume of 93 cubic yards of contaminated material at or above the 1,000 mg/kg ADEC soil target level are located in an area 25 feet by 25 feet, with an average depth of 4 feet at Navigational Aid Building 101 and an estimated volume of 16 cubic yards located in an area 12 feet by 9 feet and 10 feet by 10 feet at Navigational Aid Building 102 (Figure 7-36).

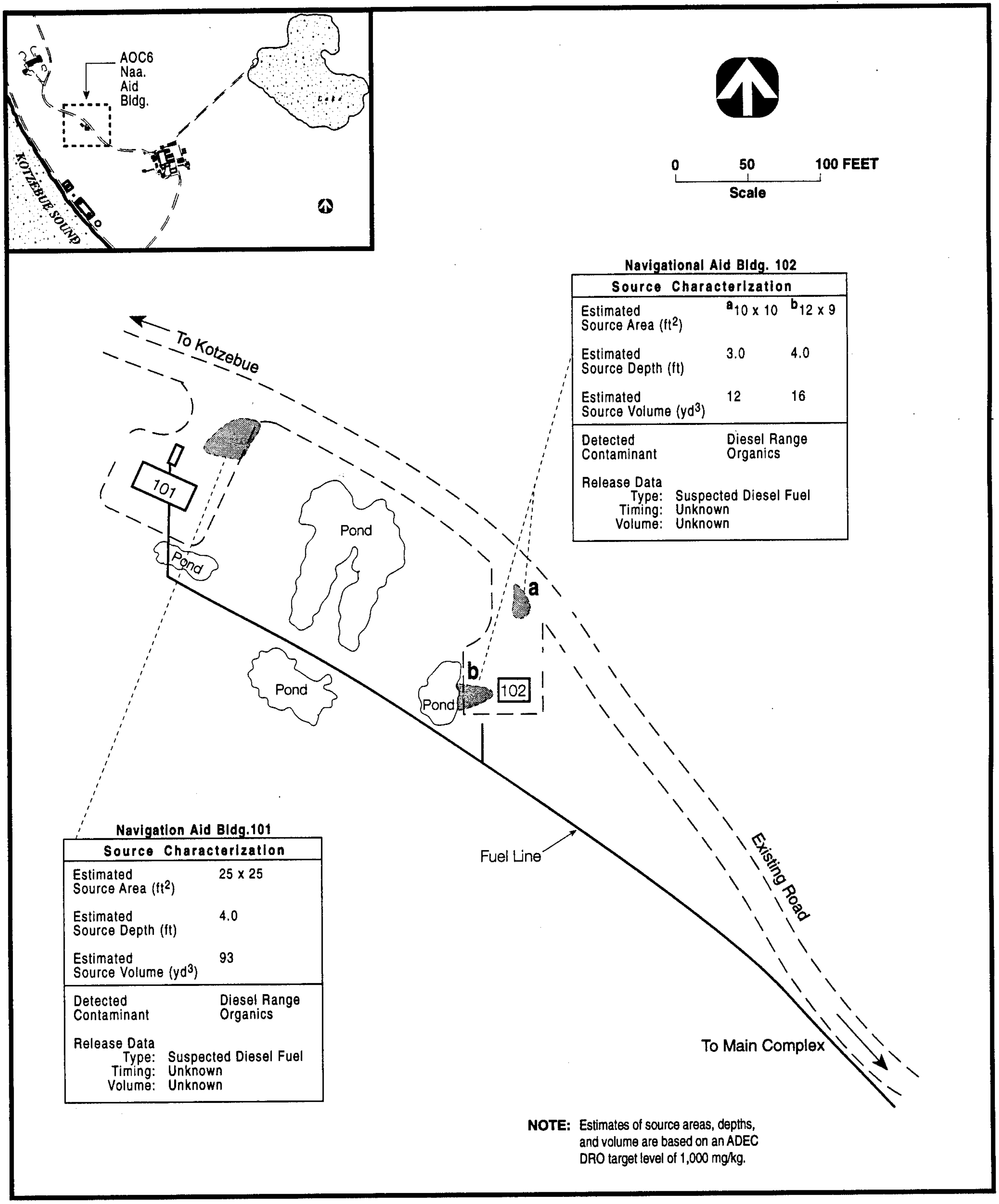


Figure 7-36. DRO Contaminant Source Characterization for Site SS16-Navigational Aid Buildings (AOC6), 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

7.17 SITE SS17-BUILDING 102

7.17.1 Summary of Site Status

Site SS17-Building 102 is a 72 square foot area of stained soil, located in a gravel driveway at the Navigational Aid Building (Building 102). Site SS17 was formally identified by the USAF based on preliminary PCB field screening results which identified PCBs in stained soil. However, subsequent analytical results for soil samples collected from the stained soil do not indicate the presence of PCBs at the site. It is suspected that elevated concentrations of petroleum hydrocarbons interfered with the PCB field test kits, causing a false positive result. The area of stained soil at Site SS17 is included in the characterization of Site SS16 (see Section 7.16, Site SS16-Navigational Aid Buildings); therefore, no further action is recommended at Site SS17. A No Further Action Decision Document will be prepared for Site SS17.

7.17.2 Site Description

Site SS17 is an area of stained soil approximately 6 feet by 12 feet, located in a gravel driveway at the Navigational Aid Building (Building 102). The area of stained soils extends from the gravel drive entrance to the edge of the facility access road (Figure 7-37). This site is incorporated in the characterization of Site SS16-Navigational Aid Buildings (see Section 7.16, Navigational Aid Buildings).

7.17.3 IRP Investigation Summary

During the 1994 RI, two surface soil samples were collected from within an area of stained soils approximately 6 feet by 12 feet, located at the Navigational Aid Building (Building 102) (Figure 7-38). The samples were screened for PCBs using Dexsil CLOR-N-SOIL^{TM} field test kits. The PCB field test kits provide a colorimetric indication of PCB concentrations equal to or greater than 50 mg/kg in soil. Field screening results detected PCBs in both soil samples collected from the stained soil. Based on these preliminary findings, the USAF formally identified the area of stained soils as Site SS17-Building 102.

During the 1994 RI, a soil sample (AOC6-SB3) was collected from the area of stained soil at Building 102. Sample AOC6-SB3 was analyzed for diesel range organics (Method AK102), volatile organic compounds (EPA Method SW 8260), semivolatile organic compounds (EPA Method SW 8270), pesticide and PCBs (EPA Method SW 8081), and metals (EPA Method 6010 series). No PCBs were detected in Sample AOC6-SB3. It is suspected that the petroleum hydrocarbon contamination found in stained soils

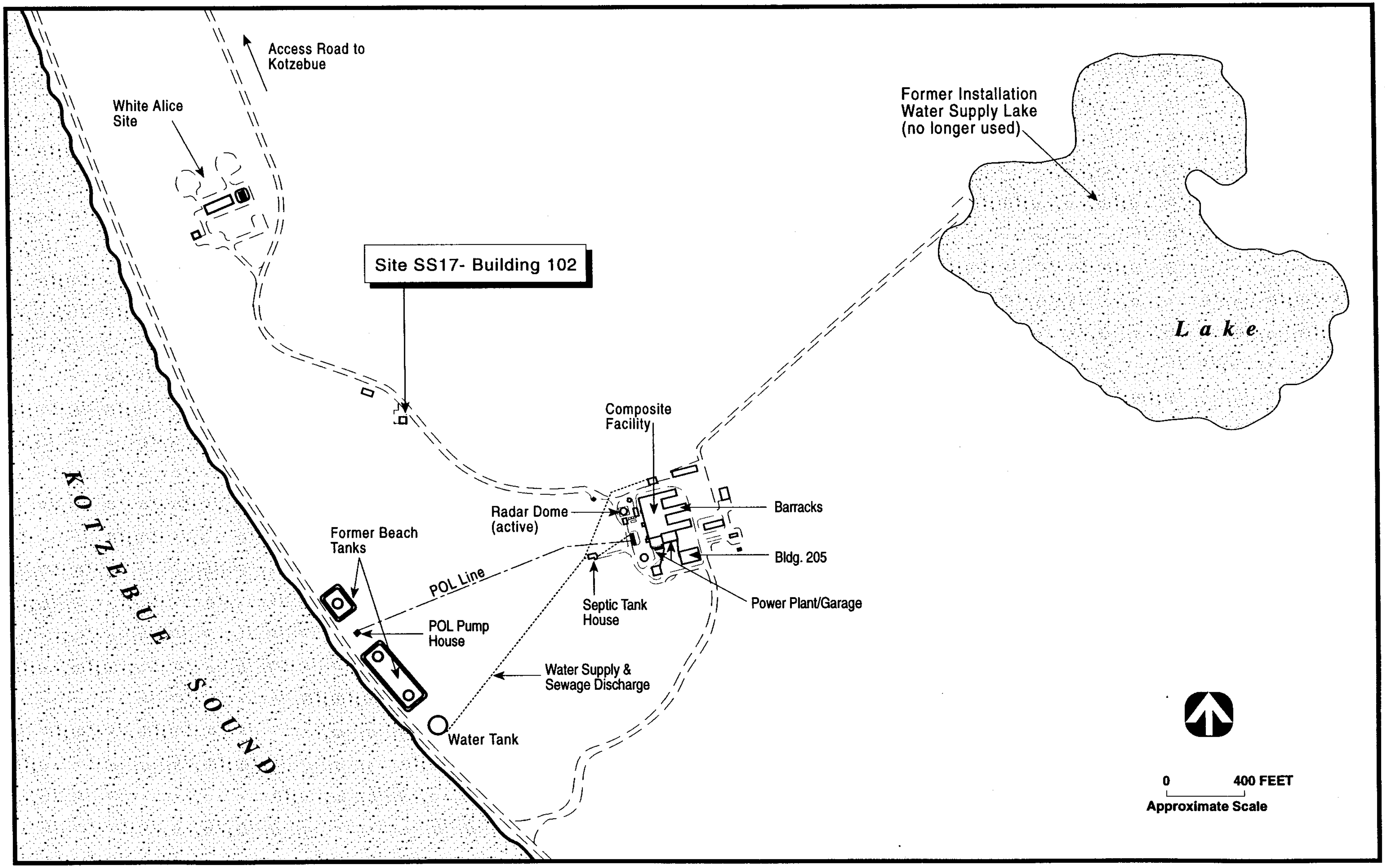
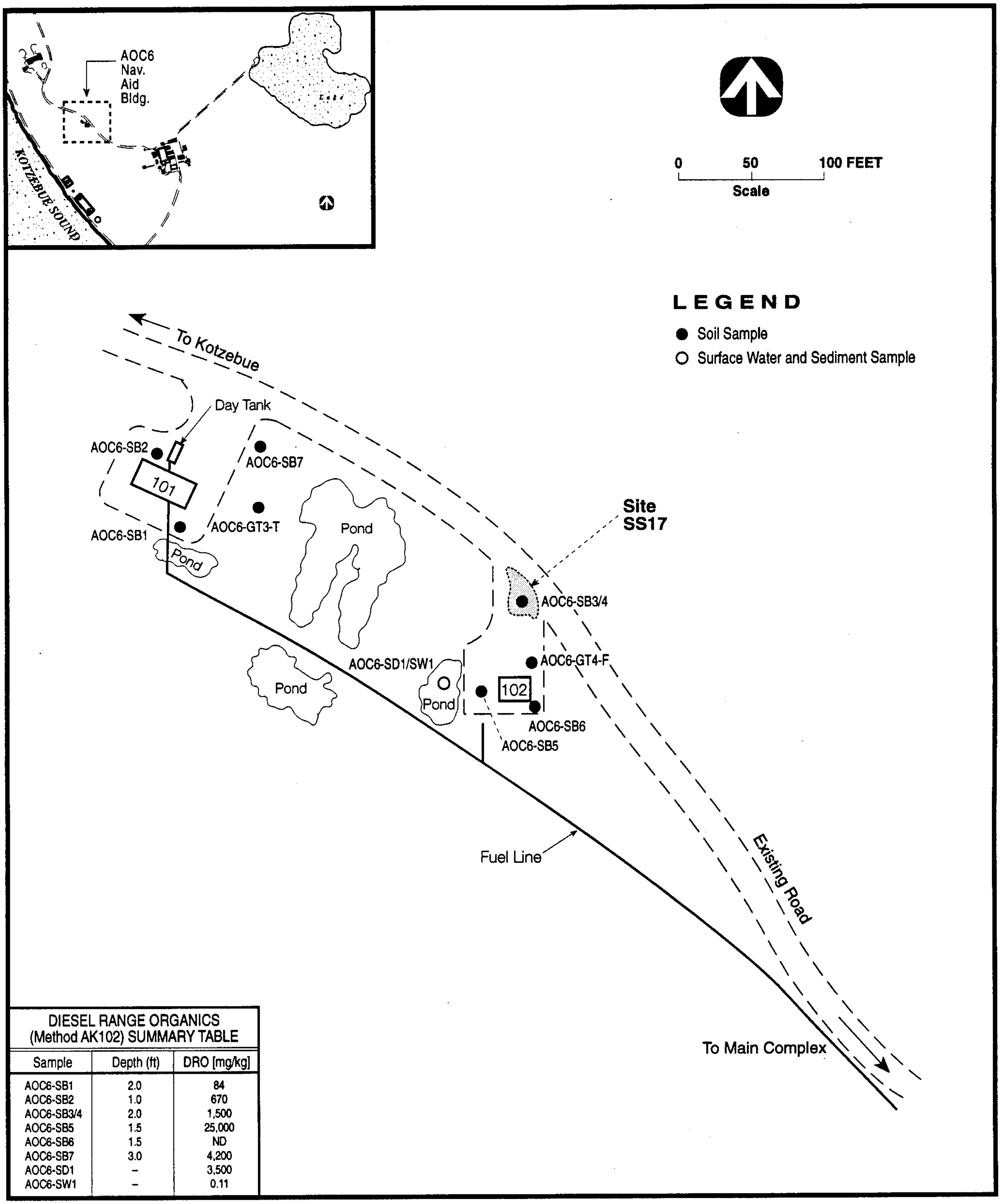


Figure 7-37. Location of Site SS17-Building 102, Kotzebue LRRS, Alaska.



DIESEL RANGE ORGANICS (Method AK102) SUMMARY TABLE		
Sample	Depth (ft)	DRO [mg/kg]
AOC6-SB1	2.0	84
AOC6-SB2	1.0	670
AOC6-SB3/4	2.0	1,500
AOC6-SB5	1.5	25,000
AOC6-SB6	1.5	ND
AOC6-SB7	3.0	4,200
AOC6-SD1	–	3,500
AOC6-SW1	–	0.11

Figure 7-38. Location of Sample Stations at Site SS17-Building 102 (AOC6), 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

interfered with the PCB field test kit, causing false positive results. A summary of maximum detected concentrations identified in the single soil sample collected at Site SS17 is provided in Section 4.5, Summary of Analytical Results; Tables 4-12 through 4-21. All sample analytical results for the 1994 RI are provided in Appendix L. The sample station location was surveyed for horizontal and vertical coordinates (see Appendix C).

7.17.4 Remaining Site Concerns

State and federal ARARs established to guide the 1994 RI are discussed in Section 4.2, Applicable or Relevant and Appropriate Requirements. Petroleum hydrocarbon contamination in gravel fill material is the only environmental concern at the site. Diesel range organics were detected in Sample AOC6-SB3 at 1,500 mg/kg, exceeding the 1,000 mg/kg ADEC soil target level.

7.17.5 Site Recommendations

Analytical results did not indicate PCBs are present in the stained soil associated with Site SS17. The area of stained soil at Site SS17 is included in the characterization of Site SS16 (see Section 7.16, Site SS16-Navigational Aid Buildings); therefore, no further action is recommended at Site SS17. A No Further Action Decision Document will be prepared for Site SS17.

7.18 SITE SS18-TRUCK FILL STAND (AOC11)

7.18.1 Summary of Site Status

Site SS18-Truck Fill Stand (AOC11) is the location of a truck fill stand located north of the active radar dome, adjacent to the facility access road. Petroleum hydrocarbons in gravel fill (up to 9,900 mg/kg) and native soils (up to 67,000 mg/kg) is the primary environmental concern at Site SS18. Site SS18 has impacted native tundra along a drainage pathway which directs runoff from the site to the southwest. It is recommended that gravel fill materials exceeding the ADEC soil target level of 1,000 mg/kg be excavated and removed from the site. Onsite treatment of contaminated fill materials is recommended to reduce petroleum hydrocarbon concentrations to acceptable levels for the onsite disposal of treated soils. Limited remedial action is recommended for native soils impacted by the site, including natural attenuation and long-term soil monitoring to evaluate environmental restoration once source materials have been removed from the site. The natural attenuation and long-term monitoring alternative represents a non-invasive, non-destructive alternative to material removal or other approaches that would negatively impact the fragile tundra environment.

7.18.2 Site Description

Site SS18 is the location of a truck fill stand located north of the active radar dome, adjacent to the facility access road (Figure 7-39). The site consists of an approximate 10 foot by 8 foot gravel pad, approximately 5 feet thick. Piping from a fuel delivery system emerges from a concrete form situated atop the gravel pad. The site has moderate drainage, with runoff from the site directed along a drainage pathway to the southwest.

7.18.3 IRP Investigation Summary

During the 1994 RI, a truck fill stand was identified north of the active radar dome, adjacent to the facility access road. Visual and olfactory evidence of petroleum hydrocarbon contamination was identified within the gravel fill material and along a drainage pathway which directs runoff from the site to the southwest. No dead vegetation was observed along the drainage pathway. The USAF identified the site as an area of concern (AOC11) for investigation during the 1994 RI. Later the USAF formally identified the site as SS18-Truck Fill Stand.

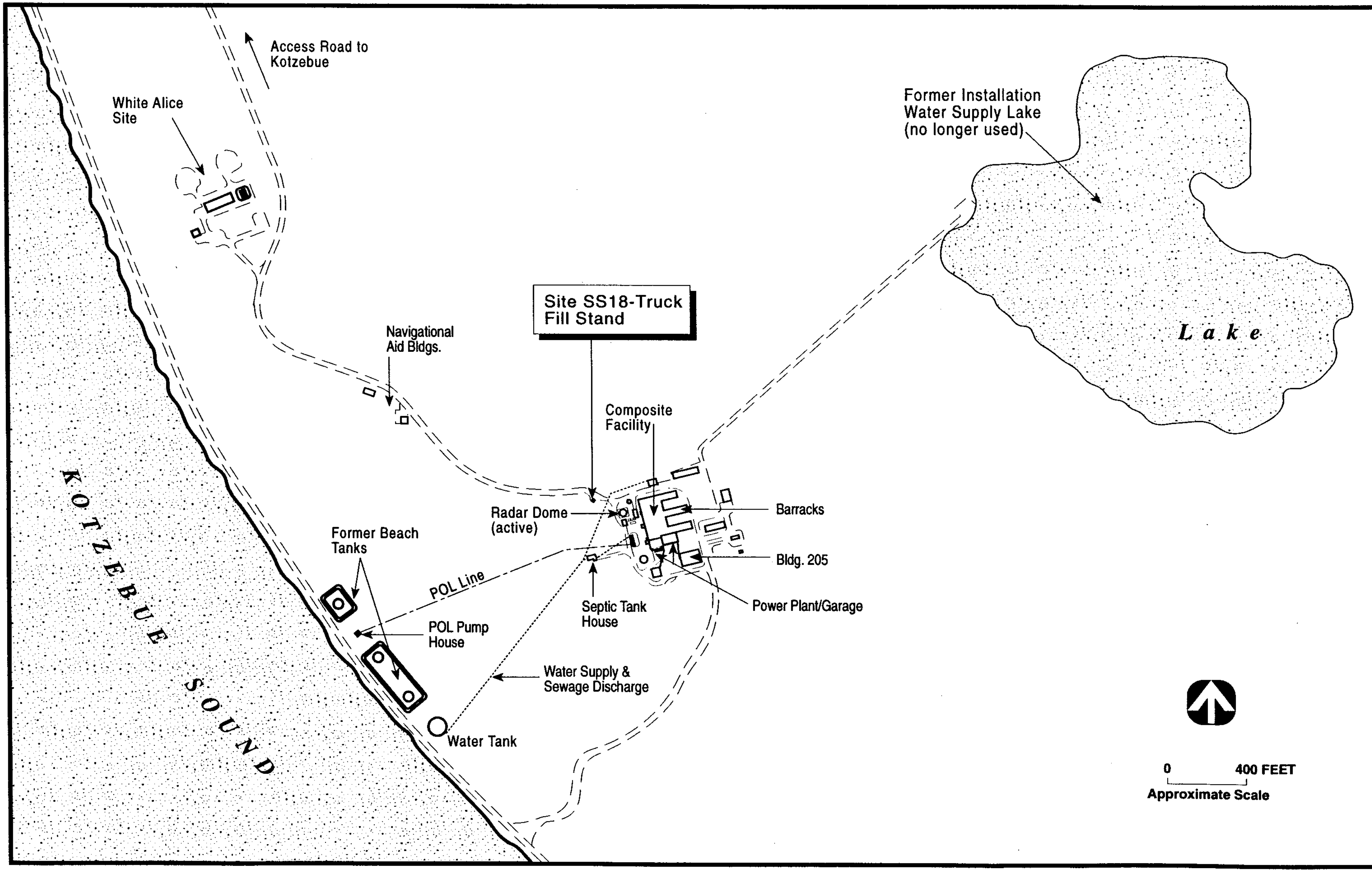


Figure 7-39. Location of Site SS18-Truck Fill Stand (AOC11), Kotzebue LRRS, Alaska.

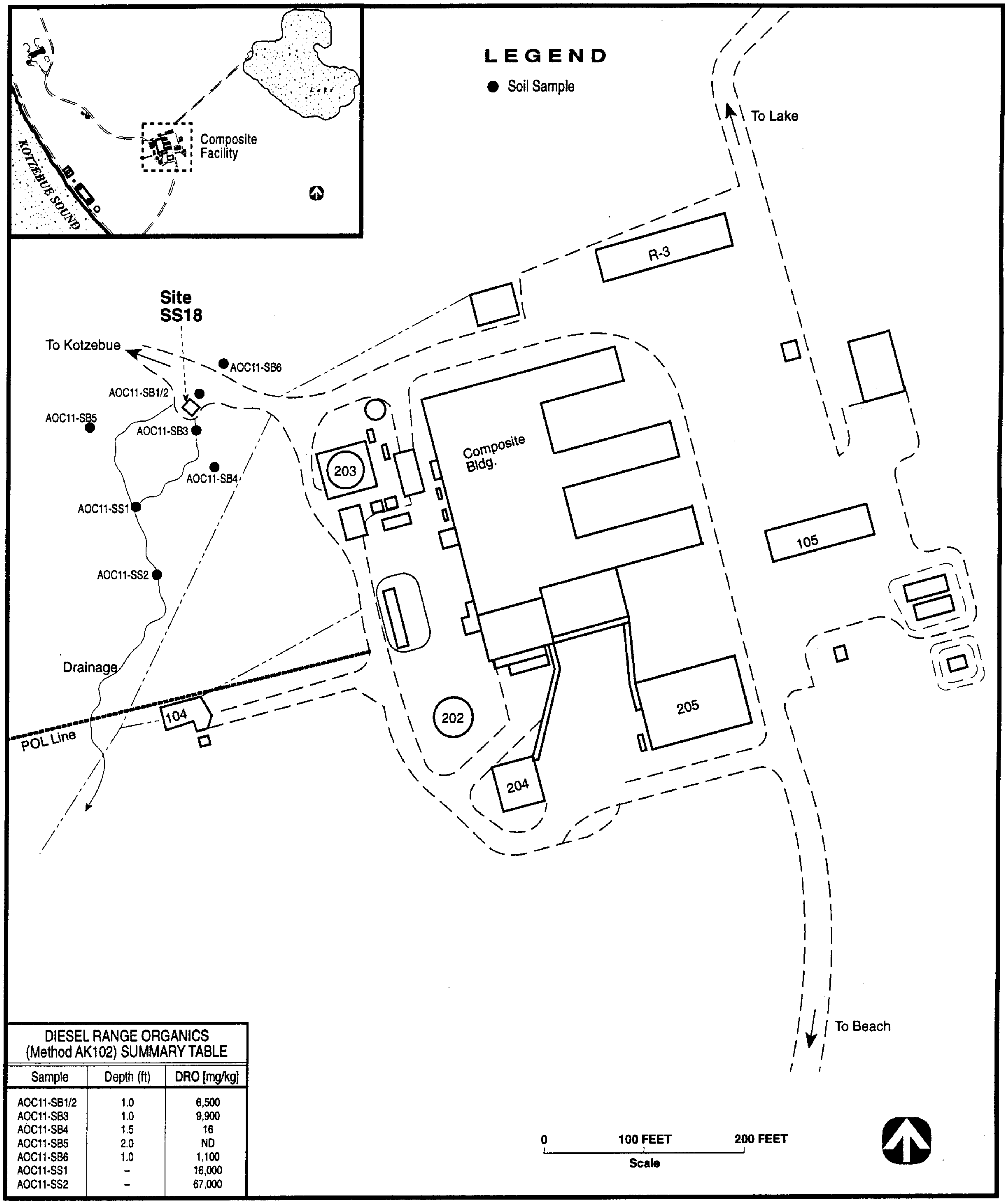
During the 1994 RI, characterization of Site SS18 included soil sampling in gravel fill and native tundra materials (Figure 7-40). Five shallow subsoil and two surface soil samples were collected for gasoline range organics (Method AK101) and diesel range organics (Method AK102) analysis. In addition, two of seven samples were submitted for volatile organic compounds (EPA Method SW 8260), semivolatile organic compounds (EPA Method SW 8270), and metals (EPA Method 6010 series). A summary of maximum detected concentrations identified at Site SS16 is provided in Section 4.5, Summary of Analytical Results; Tables 4-12 through 4-16. All sample analytical results for the 1994 RI are provided in Appendix L. All sample station locations were surveyed for horizontal and vertical coordinates (see Appendix C).

7.18.4 Remaining Site Concerns

State and federal ARARs established to guide the 1994 RI are discussed in Section 4.2, Applicable or Relevant and Appropriate Requirements. Petroleum hydrocarbon contamination in gravel fill and native tundra materials is the primary environmental concern at Site SS18. Four of seven soil samples revealed elevated gasoline range organics, including Sample AOC11-SS1 at 980 mg/kg, Sample AOC11-SB2 at 2,100 mg/kg, Sample AOC11-SB1 at 1,500 mg/kg, and Sample AOC11-SB3 at 920 mg/kg (see Figure 7-40). Five of seven soil samples contained diesel range organics in excess of the 1,000 mg/kg ADEC soil target level, with a maximum concentration observed in Sample AOC6-SS2 of 67,000 mg/kg (see Figure 7-40). In support of the 1994 remedial investigation, a baseline risk assessment was conducted which indicates no significant ecological risks were identified for soil at Site SS18. The health based risk assessment indicated a potential risk to human health for soil ingestion (1.66E-6) and inhalation of airborne dust (2.14E-6) pathways based on the detection of arsenic in Sample AOC11-SB1/2 at 7 mg/kg. Although site soil samples exceed health based threshold criteria for arsenic (i.e., 4.74 mg/kg for ingestion and 4.61 mg/kg for inhalation), their concentrations are less than the arithmetic mean concentration of arsenic measured in background soil samples (i.e., 27 mg/kg). No known sources of arsenic are identified for Site SS18 and the detection of arsenic in background locations indicate this element is naturally occurring. The average concentration of arsenic in natural soils is reportedly 5 mg/kg, but can range from 1 mg/kg to 50 mg/kg (EPA 1983).

7.18.5 Site Recommendations

Site SS18 has contaminated fill material and impacted native tundra along a drainage pathway (see Figure 7-40). It is recommended that gravel fill materials exceeding the ADEC soil target level of 1,000 mg/kg



DIESEL RANGE ORGANICS (Method AK102) SUMMARY TABLE		
Sample	Depth (ft)	DRO [mg/kg]
AOC11-SB1/2	1.0	6,500
AOC11-SB3	1.0	9,900
AOC11-SB4	1.5	16
AOC11-SB5	2.0	ND
AOC11-SB6	1.0	1,100
AOC11-SS1	-	16,000
AOC11-SS2	-	67,000

Figure 7-40. Location of Sample Stations at Site SS18-Truck Fill Stand (AOC11), 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

be excavated and removed from the site. Onsite treatment of contaminated fill materials is recommended to reduce petroleum hydrocarbon concentrations to acceptable levels for the onsite disposal of treated soils. The estimated 278 cubic yard of contaminated material at or above the 1,000 mg/kg ADEC target level are located in an area 50 by 30 feet, with an estimated average depth of 5 feet (Figure 7-41).

Limited action is recommended for native soils impacted by the site, including natural attenuation and long-term soil monitoring to evaluate environmental restoration once source materials have been removed from the site. The natural attenuation and long-term monitoring alternative represents a non-invasive, non-destructive alternative to material removal or other approaches that would negatively impact the fragile tundra environment. Biannual monitoring is recommended for native tundra impacted at Site SS18, including visual inspection and photographs to document site conditions once suspected source materials have been removed. Monitoring should incorporate limited soil sample collection for diesel range organics to evaluate the effectiveness of the natural attenuation alternative. Soil sample(s) should be collected from location(s) (in native tundra) which revealed elevated DRO concentrations during the 1994 RI to assure appropriate comparison between monitoring events. Data obtained from biannual monitoring should be evaluated to determine the effectiveness of natural attenuation and to assess the need and/or requirements for subsequent monitoring of Site SS18.

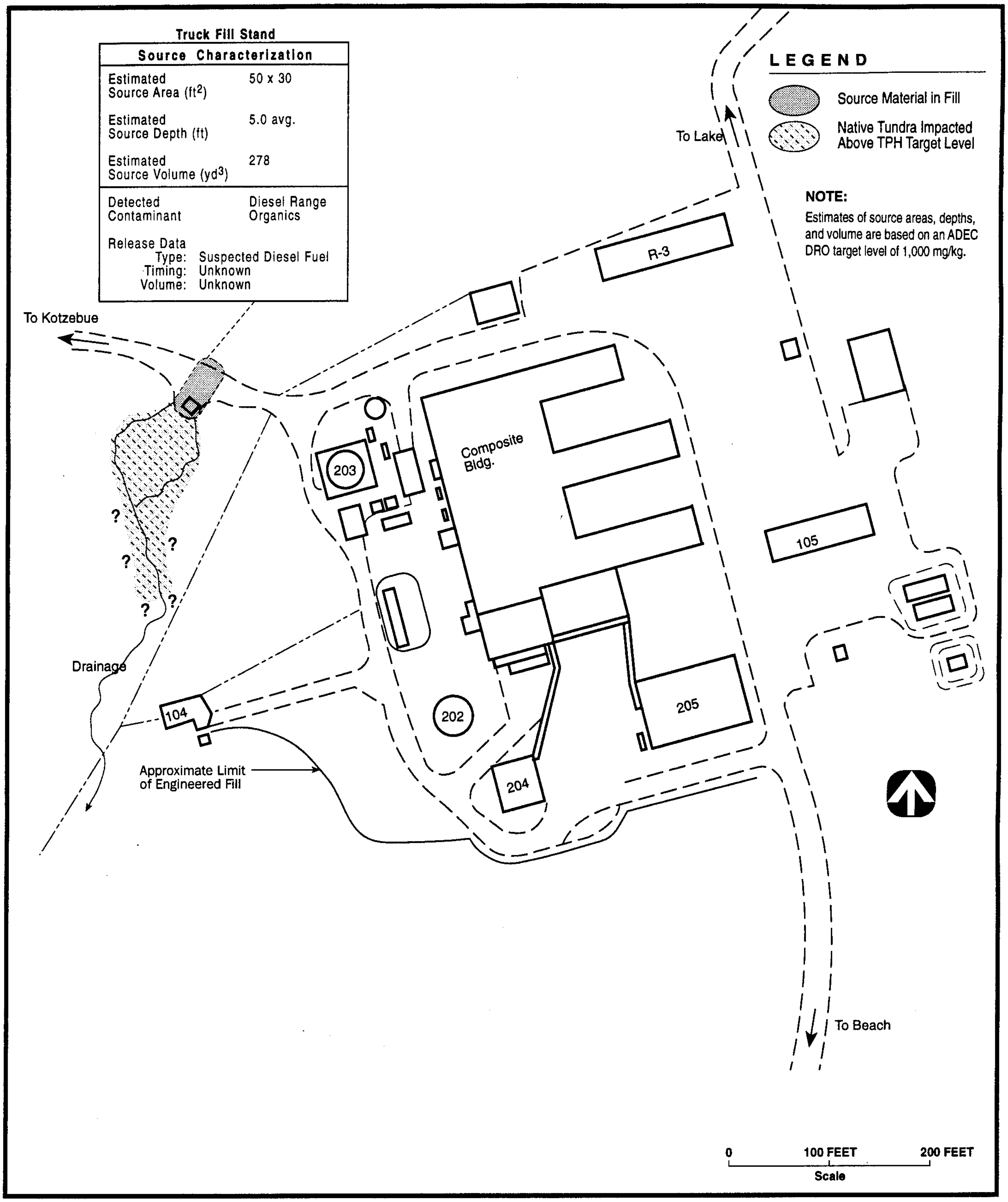


Figure 7-41. DRO Contaminant Source Characterization at Site SS18-Truck Fill Stand (AOC11), 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

7.19 SITE SS19-PCB SPILL SOUTH FENCE (AOC12)

7.19.1 Summary of Site Status

Site SS18-PCB Spill South Fence (AOC12) is a small (100 square foot) but distinct area of stained soil in gravel fill material located approximately 30 feet west of the active radar dome. Petroleum hydrocarbons in gravel fill (up to 27,000 mg/kg) is the primary environmental concern at Site SS18. Petroleum hydrocarbon concentrations in gravel fill materials at Site SS19 represent a potential source of contamination to nearby native vegetation. To mitigate the potential impact to native tundra, it is recommended that gravel fill materials exceeding the ADEC soil target level of 1,000 mg/kg be excavated and removed from the site. Onsite treatment of contaminated fill materials is recommended, to reduce petroleum hydrocarbon concentrations to acceptable levels for the onsite disposal of treated soils.

7.19.2 Site Description

Site SS18 is a small (100 square foot) but distinct area of stained soil in gravel fill material located approximately 30 feet west of the active radar dome (Figure 7-42). Facility fencing transects the stained soil area. The site moderately slopes to the west where the edge of the gravel pad contacts native tundra. Surface runoff from the site is to the southwest through native tundra.

7.19.3 IRP Investigation Summary

During the 1994 RI, a small but distinct area of stained soil (gravel fill material) was identified approximately 30 feet west of the active radar dome. Visual and olfactory evidence of petroleum hydrocarbon contamination was observed in gravel fill materials. No evidence of petroleum hydrocarbon contamination was found in native soils adjacent to the site. The USAF identified the site as an area of concern (AOC12) for investigation during the 1994 RI. Two surface soil samples were collected from within the area of stained soil and screened for PCBs using Dexsil CLOR-N-SOIL™ field test kits. The Dexsil field test kits provide a colorimetric indication of PCB concentrations equal to or greater than 50 mg/kg in soil. Field screening results indicated PCBs detected in one of the two soil samples tested. Based on field screening results, the USAF formally identified the area of stained soil as Site SS19-PCB Spill South Fence.

During the 1994 RI, a soil sample (AOC12-SS1) was collected from the area of stained soil along the fence adjacent to the active radar dome (Figure 7-43). The soil sample was analyzed for diesel range

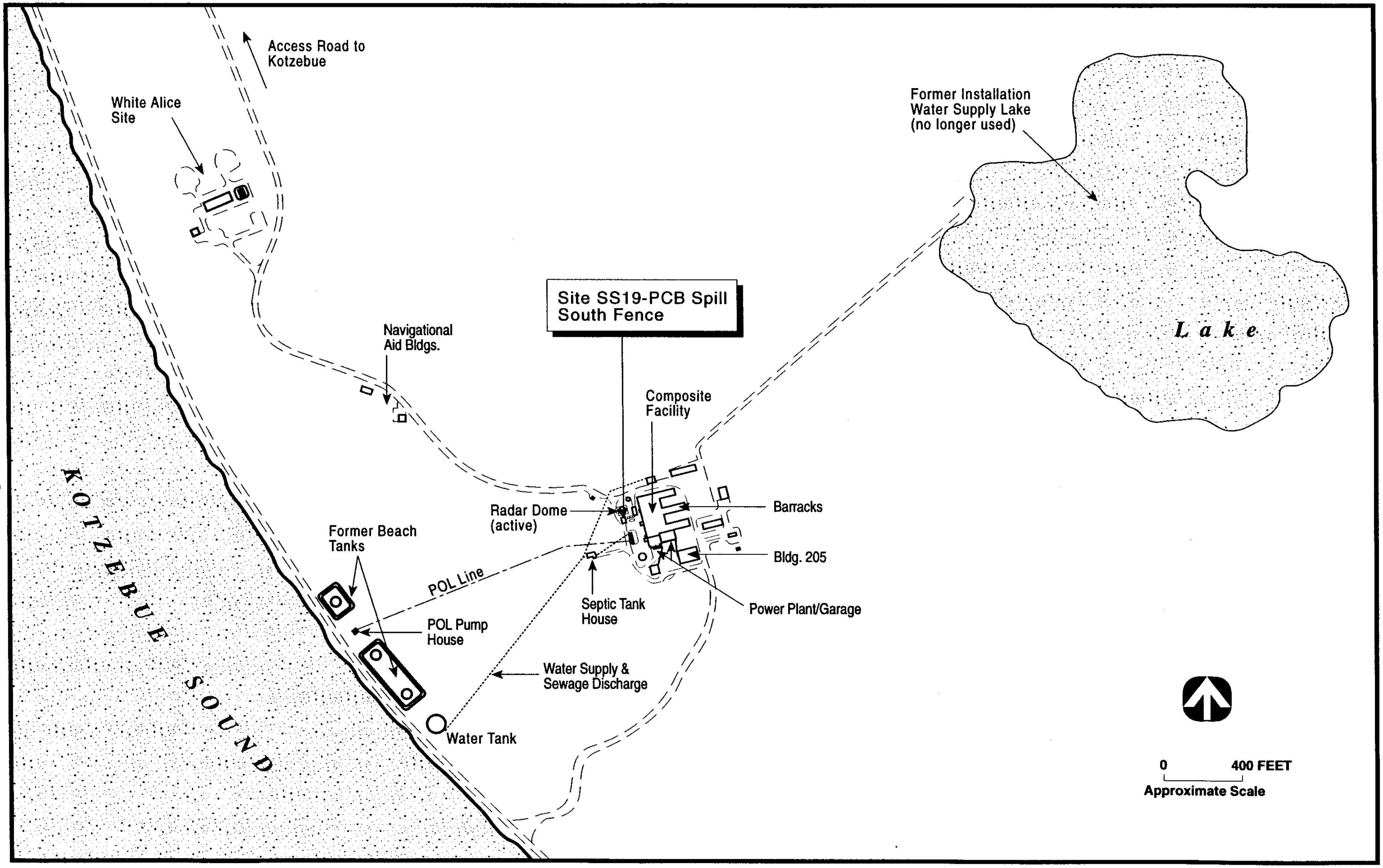
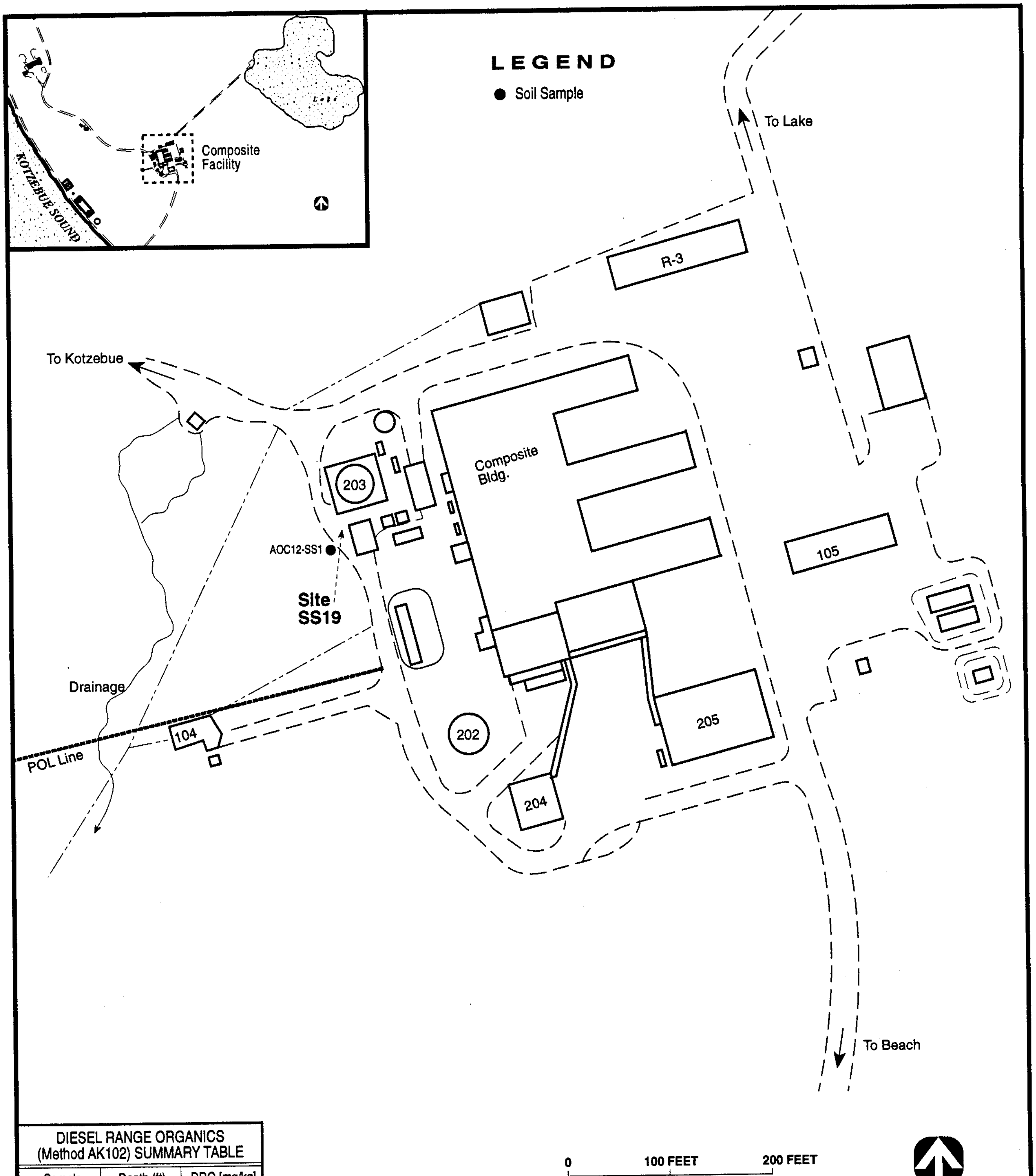


Figure 7-42. Location of Site SS19-PCB Spill South Fence (AOC12), Kotzebue LRRS, Alaska.



DIESEL RANGE ORGANICS (Method AK102) SUMMARY TABLE		
Sample	Depth (ft)	DRO [mg/kg]
AOC12-SS1	<1.0	27,000

Figure 7-43. Location of Sample Stations at Site SS19-PCB Spill South Fence (AOC12), 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

organics (Method AK102), volatile organic compounds (EPA Method SW 8260), semivolatile organic compounds (EPA Method SW 8270), and pesticides and PCBs (EPA Method SW8081). PCBs were not detected in Sample AOC12-SS1. It is suspected that the elevated concentrations of petroleum hydrocarbons interfered with the PCB field test kit, causing a false positive result. A summary of maximum detected concentrations identified at Site SS19 is provided in Section 4.5, Summary of Analytical Results; Tables 4-12 through 4-16. All sample analytical results for the 1994 RI are provided in Appendix L. Figure 4-43 provides 1994 RI sample station locations at Site SS19. All sample station locations were surveyed for horizontal and vertical coordinates (see Appendix C).

7.19.4 Remaining Site Concerns

No significant ecological or human health risks were identified for soil at Site SS19. State and federal ARARs established to guide the 1994 RI are discussed in Section 4.2, Applicable or Relevant and Appropriate Requirements. Petroleum hydrocarbon contamination in gravel fill is the primary environmental concern at Site SS19. Soil sample AOC12-SS1 contained diesel range organics at 27,000 mg/kg, exceeding the 1,000 mg/kg ADEC soil target level for Kotzebue LRRS (see Figure 4-43).

7.19.5 Site Recommendations

Petroleum hydrocarbon concentrations in gravel fill materials at Site SS19 provide a potential source of contamination to nearby native vegetation. To mitigate the potential impact to native tundra it is recommended that gravel fill materials exceeding the ADEC soil target level of 1,000 mg/kg be excavated and removed from the site. Onsite treatment of contaminated fill materials is recommended to reduce petroleum hydrocarbon concentrations to acceptable levels for the onsite disposal of treated soils. The estimated 12 cubic yards of contaminated material at or above the 1,000 mg/kg ADEC soil target level are located in an area 10 by 10 feet, with an average estimated depth of 3 feet (Figure 7-44).

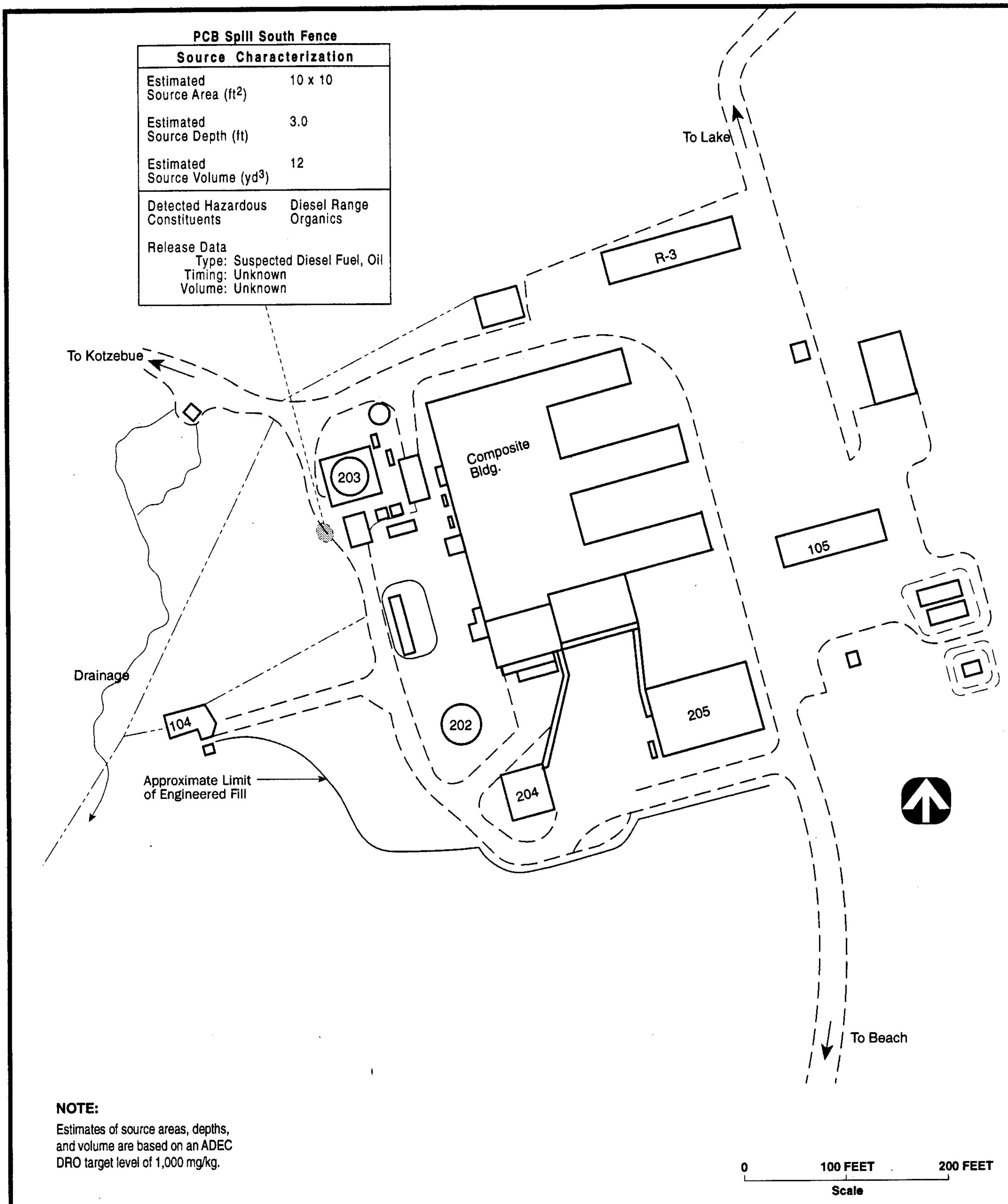


Figure 7-44. DRO Contaminant Source Characterization at Site SS19-PCB Spill South Fence (AOC12), 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

7.20 AOC2-POL LINE

7.20.1 Summary of Site Status

AOC2-POL Line is a 2-inch diameter steel pipeline used to transport diesel fuel from the former beach fuel storage tanks to the Composite Facility. Petroleum hydrocarbons in soil (at 5,100 mg/kg) is the primary environmental concern at the site. Petroleum hydrocarbon contamination was limited to Sample AOC2-SB1, collected from the upper end of the accessible pipeline where it enters the gravel fill. However, this sample location is located within Site SS12-Spills No. 2 and 3, and the detection of petroleum hydrocarbons in sample AOC2-SB1 is likely residual contamination from Spills No. 2 and 3 (see Section 7.12, Site SS12-Spills No. 2 and 3). Based on results from a POL Line survey indicating no holes or breaks in the pipeline and no evidence of leaking or stressed vegetation along the pipeline, no further action is recommended at AOC2-POL Line. The POL Line is not formally identified as a site at Kotzebue LRRS; therefore, no closure documents are required.

7.20.2 Site Description

The POL line is a 2-inch diameter steel pipeline used to transport diesel fuel from the former beach fuel storage tanks to the Composite Facility. The POL Line runs from the beach area uphill to the main facility (Figure 7-45).

7.20.3 IRP Investigation Summary

Previous investigations have not included an assessment of the POL Line at Kotzebue LRRS. Therefore, the USAF identified the pipeline as an area of concern (AOC2) for investigation during the 1994 RI. AOC2-POL Line was characterized during the 1994 RI, including a pipeline survey and soil sample collection.

7.20.3.1 AOC2-POL Line Survey. On 17 June 1994, a visual survey was conducted along the accessible length of the pipeline to identify holes, loose or disconnected joints and fittings, and any evidence of past leaks. Based on the inspection, the accessible section of the POL line extends from the gravel fill beneath the fenced western perimeter of the Composite Facility, across the gently sloping tundra covered hill, to a point where the pipeline crosses the steeper bluff face to the beach. Vegetation present on the bluff is too thick to allow inspection of the POL line without removal of the vegetative cover. The pipeline is cut and capped where it extends out from this vegetative cover onto the beach, approximately 100 feet

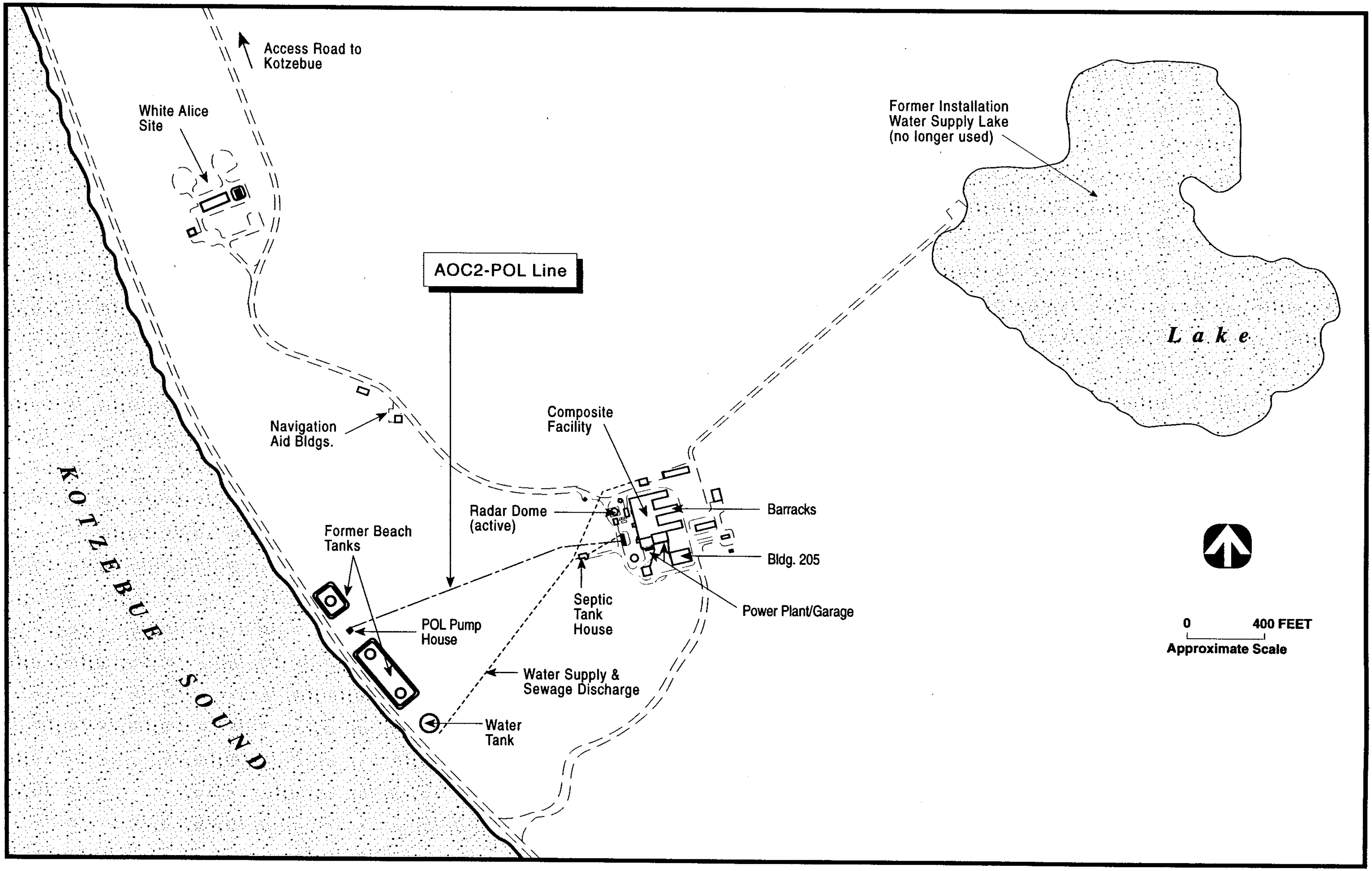


Figure 7-45. Location of AOC2-POL Line, Kotzebue LRRS, Alaska.

east of the pumphouse (see Figure 7-45). The piping between the capped end and the pumphouse was removed at some point in the past. The POL Line consists of a 2-inch diameter steel pipe with welded connections. No holes or breaks were detected in the accessible portion of the pipe inspected. No evidence of fuel leaks or stressed vegetation caused by past fuel leaks was observed.

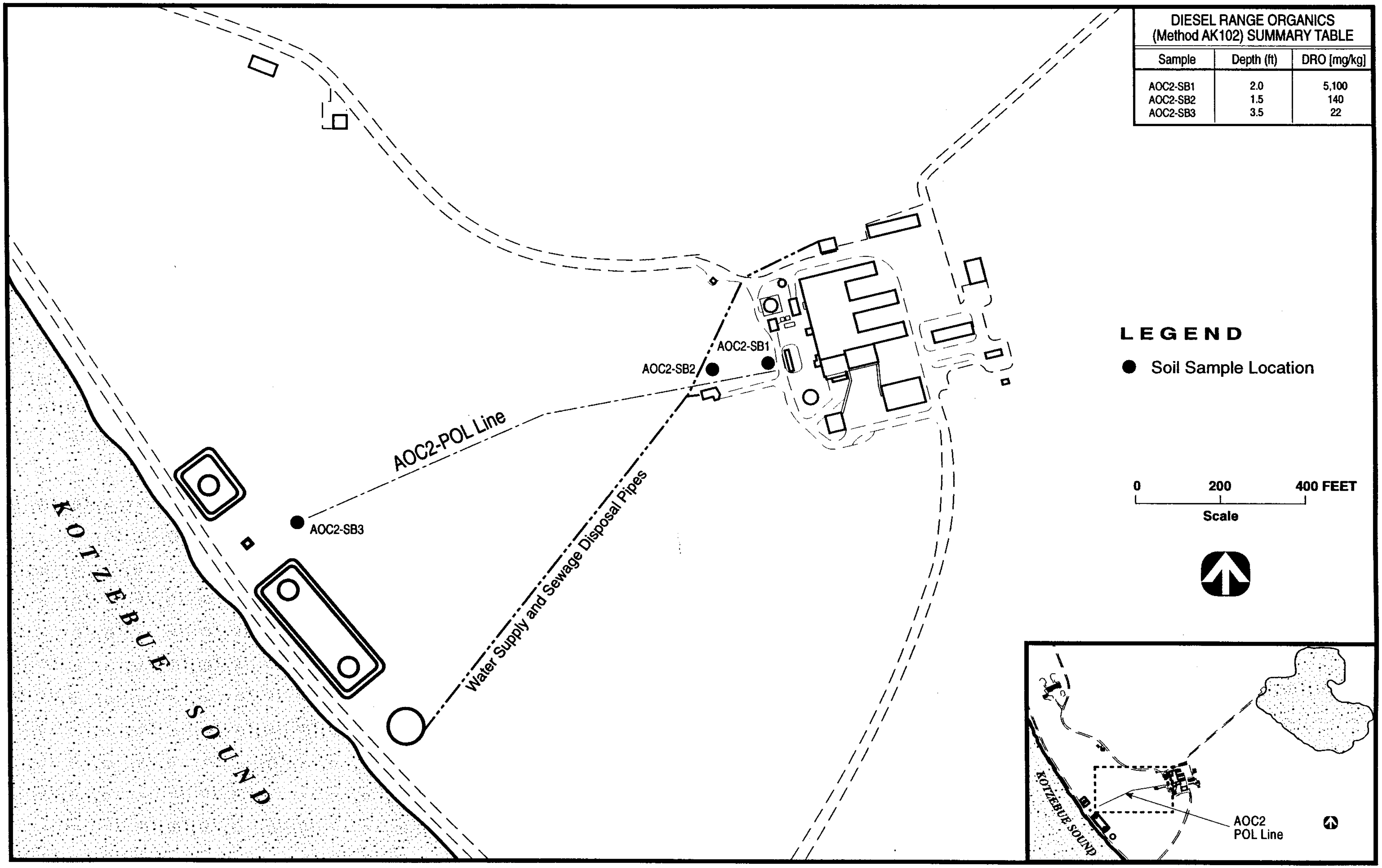
7.20.3.2 Soil Sampling. Based on the inspection of the POL Line, three sample locations were selected along the pipeline, including: 1) one sample location at the upper end of the accessible pipeline where it enters the gravel fill (AOC2-SB1); 2) one sample location in a topographically low spot just up-slope from the septic tank building (AOC2-SB2); and 3) one sample location on the back of the beach where the pipeline is cut and capped (AOC2-SB3). Figure 7-46 shows the location of the POL Line and associated sample locations. All samples were analyzed for diesel range organics (Method AK102), volatile organic compounds (EPA Method SW8260), semivolatile compounds (EPA Method SW 8270), and pesticides and PCBs (EPA Method SW8081). A summary of maximum detected concentrations identified at Site AOC2 is provided in Section 4.5, Summary of Analytical Results; Tables 4-12 through 4-16. All sample analytical results for the 1994 RI are provided in Appendix L. All sample station locations were surveyed for horizontal and vertical coordinates (see Appendix C).

7.20.4 Remaining Site Concerns

State and federal ARARs established to guide the 1994 RI are discussed in Section 4.2, Applicable or Relevant and Appropriate Requirements. One of three soil samples collected (AOC2-SB1 at 5,100 mg/kg) revealed elevated diesel range organics exceeding the 1,000 mg/kg ADEC soil target level. No significant ecological or human health risks were identified for soils at Site AOC2.

7.20.5 Site Recommendations

Petroleum hydrocarbon contamination was limited to Sample AOC2-SB1, collected from the upper end of the accessible pipeline where it enters the gravel fill (see Figure 4-46). However, this sample location is located within Site SS12-Spills No. 2 and 3, and the detection of petroleum hydrocarbons in sample AOC2-SB1 is likely residual contamination from Spills No.2 and 3 (see Section 7.12, Site SS12-Spills No. 2 and 3). Based on results from a POL Line survey indicating no holes or breaks in the pipeline and no evidence of leaking or stressed vegetation along the pipeline, no further action is recommended at AOC2-POL Line. The POL Line is not formally identified as a site at Kotzebue LRRS; therefore, no closure documents are required.



DIESEL RANGE ORGANICS (Method AK102) SUMMARY TABLE

Sample	Depth (ft)	DRO [mg/kg]
AOC2-SB1	2.0	5,100
AOC2-SB2	1.5	140
AOC2-SB3	3.5	22

Figure 7-46. Location of Sampling Stations at AOC2-POL Line, 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

7.21 AOC5-SMALL DAY TANKS

7.21.1 Summary of Site Status

AOC5-Small Day Tanks includes nine locations where small above-ground day tanks which were formerly used throughout the installation for heating and equipment operation. Petroleum hydrocarbons detected in soil above the ADEC soil target level of 1,000 mg/kg at nine day tank locations are the primary environmental concern at AOC5. Formal USAF site identification is recommended for AOC5-Small Day Tanks. It is recommended that all day tanks no longer in use at Kotzebue LRRS be inspected to verify that no fuel remains in tanks or associated piping at the site. Fuel identified (if any) during inspection should be removed and properly contained to eliminate any potential for further release. To mitigate potential impacts to native tundra and eliminate potential human health or ecological concerns, it is recommended that gravel fill materials exceeding the ADEC soil target level of 1,000 mg/kg be excavated and removed from the site. Onsite treatment of contaminated fill materials is recommended to reduce diesel range organics to acceptable levels for the onsite disposal of treated soil.

7.21.2 Site Description

AOC5 represents a number of small (approximately 250 gallon) above-ground day tanks which were formerly used throughout the installation for heating and equipment operation. The day tanks at Kotzebue LRRS were reportedly drained of any remaining fuel in 1993. Nine day tank locations were investigated during the 1994 RI at Kotzebue LRRS (Figure 7-47).

7.21.3 IRP Investigation Summary

In 1993, a site survey of Kotzebue LRRS was conducted to evaluate current site conditions, identify potential areas of concern, and obtain information necessary to prepare RI/FS scoping documents for the 1994 IRP field activities. No previous assessment of day tanks had been conducted at Kotzebue LRRS. The USAF identified the small day tanks (as a group) as an area of concern (AOC5-Small Day Tanks) for investigation during the 1994 RI, based on the potential for historical diesel fuel releases due to spills (overfilling) or leaking from the tanks or tank lines.

During the 1994 RI, 13 day tanks at nine locations were characterized by collecting soil samples to evaluate the nature and extent of potential contamination (Table 7-16). Figure 7-48 identifies the sample stations at AOC5. A summary of maximum detected concentrations identified for AOC5 is provided in

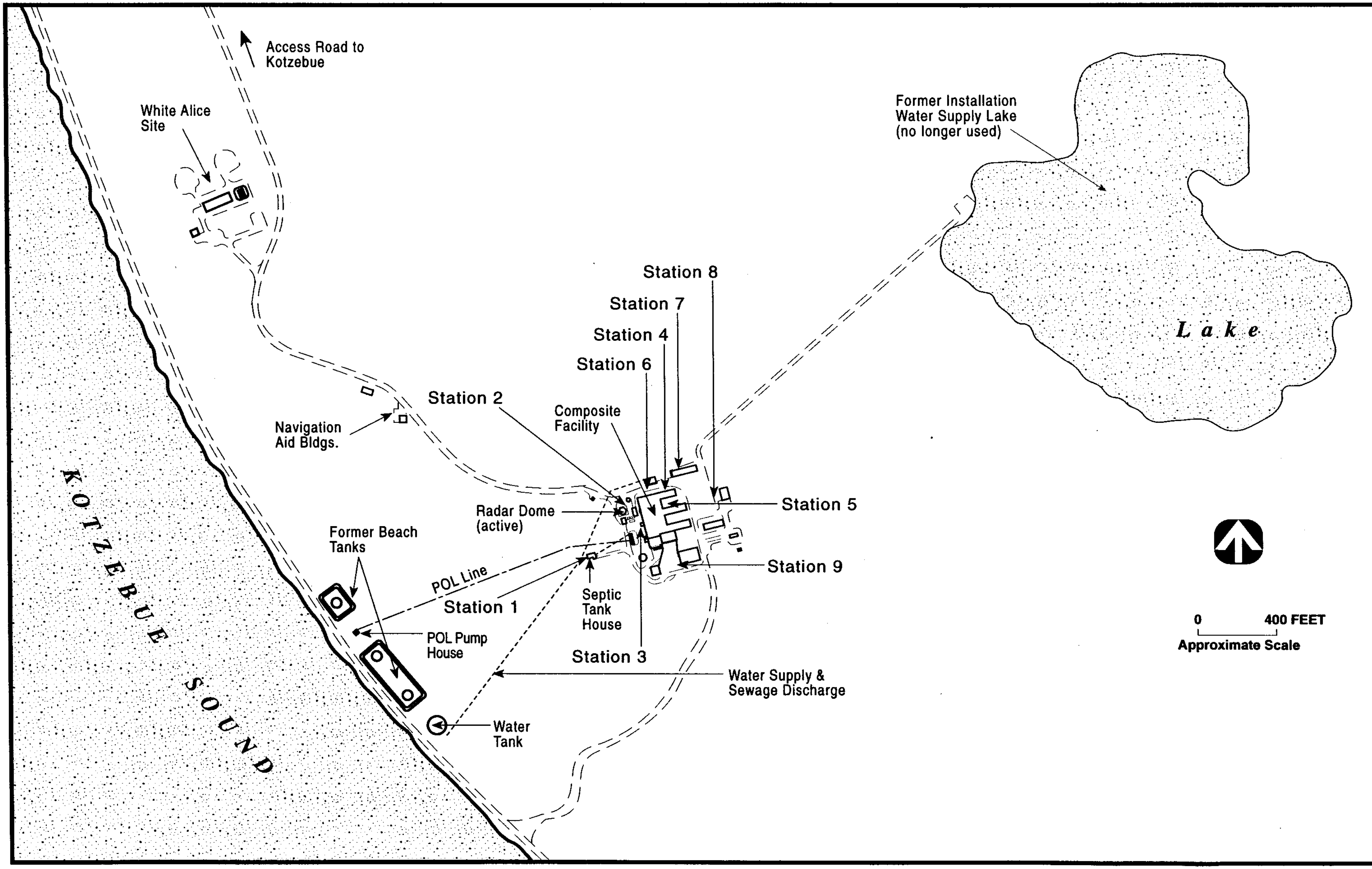
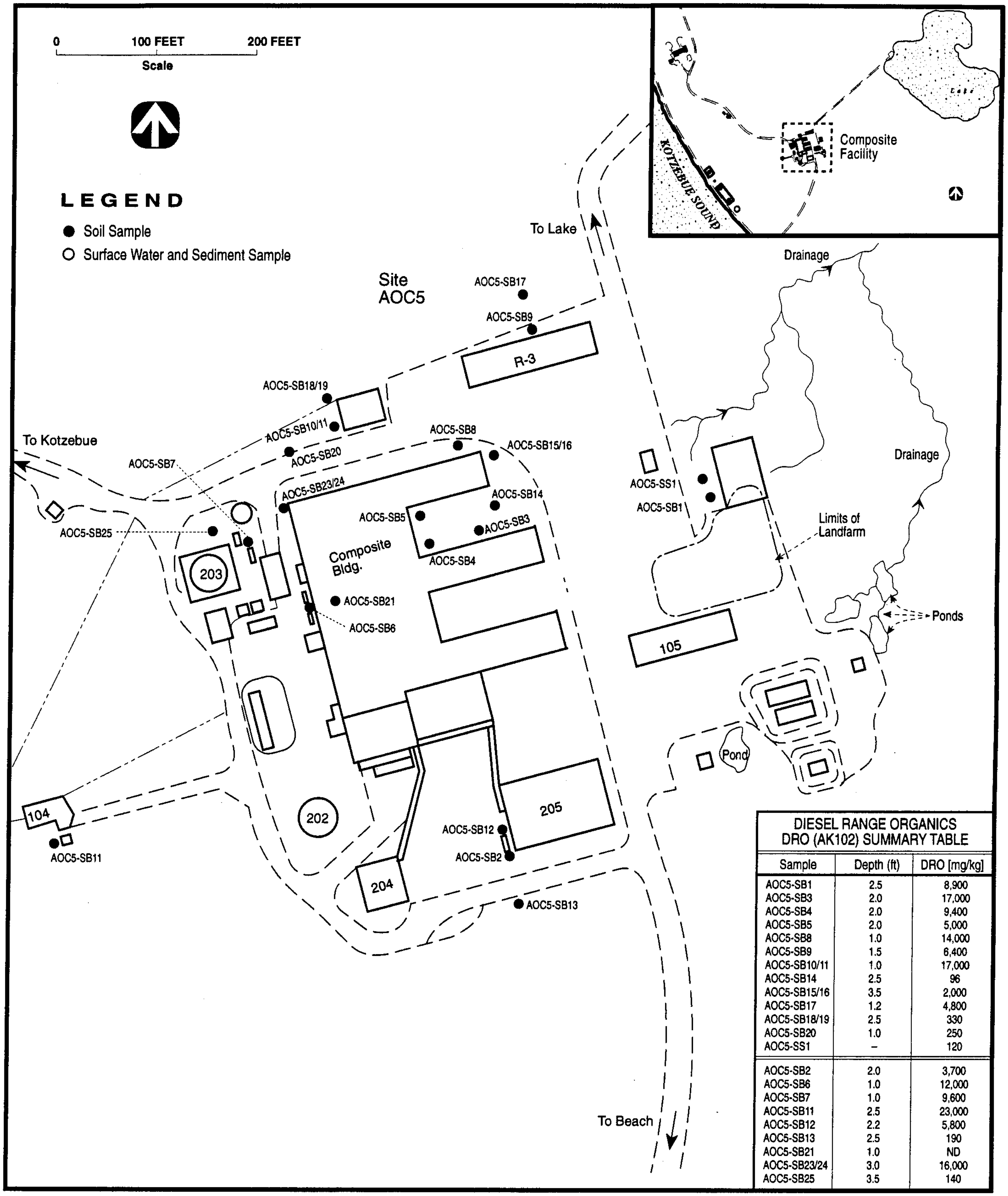


Figure 7-47. Location of AOC5-Small Day Tanks, Kotzebue LRRS, Alaska.

TABLE 7-16. 1994 REMEDIAL INVESTIGATION ACTIVITIES SUMMARY FOR AOC5-SMALL DAY TANKS, KOTZEBUE LRRS, ALASKA

Day Tank Location Designation	Day Tank Description	Field Sampling	Analyses Performed	Field Activities
1	One day tank is located adjacent to the south side of the septic holding tank (Bldg. 104)	1 Soil Sample (AOC5-SB11)	Diesel Range Organics (Method AK102) Volatile Organic Compounds (EPA Method SW 8260) Semivolatile Organic Compounds (EPA Method SW 8270) Pesticides and PCBs (EPA Method SW 8081)	All sample locations were surveyed
2	Two day tanks are located adjacent to the northeast corner of the active radar dome (Bldg. 203)	2 Soil Samples (AOC5-SB7 and SB25)	(2) Diesel Range Organics (Method AK102) (1) Volatile Organic Compounds (EPA Method SW 8260) (1) Semivolatile Organic Compounds (EPA Method SW 8270) (1) Pesticides and PCBs (EPA Method SW 8081)	All sample locations were surveyed
3	Two day tanks are located adjacent to the west central side of the Composite Facility	2 Soil Samples (AOC5-SB6 and SB21)	(2) Diesel Range Organics (Method AK102) (1) Volatile Organic Compounds (EPA Method SW 8260) (1) Semivolatile Organic Compounds (EPA Method SW 8270) (1) Pesticides and PCBs (EPA Method SW 8081)	All sample locations were surveyed
4	One day tank is located adjacent to the northeast corner of the Composite Facility	2 Soil Samples (AOC5-SB8 and SB15)	(2) Diesel Range Organics (Method AK102) (1) Volatile Organic Compounds (EPA Method SW 8260) (1) Semivolatile Organic Compounds (EPA Method SW 8270) (1) Pesticides and PCBs (EPA Method SW 8081)	All sample locations were surveyed
5	Three day tanks are located in the northern corridor (wing) of the Composite Facility	4 Soil Samples (AOC5-SB3, SB4, SB5, and SB14)	(4) Diesel Range Organics (Method AK102) (3) Volatile Organic Compounds (EPA Method SW 8260) (3) Semivolatile Organic Compounds (EPA Method SW 8270) (3) Pesticides and PCBs (EPA Method SW 8081)	All sample locations were surveyed
6	One day tank is located across the facility access road north of the Composite Facility	3 Soil Samples (AOC5-SB10, SB18, and SB20)	(3) Diesel Range Organics (Method AK102) (1) Volatile Organic Compounds (EPA Method SW 8260) (1) Semivolatile Organic Compounds (EPA Method SW 8270) (1) Pesticides and PCBs (EPA Method SW 8081)	All sample locations were surveyed
7	Day tank is adjacent to the northern side of Building R-3	2 Soil Samples (AOC5-SB9 and SB17)	(2) Diesel Range Organics (Method AK102) (1) Volatile Organic Compounds (EPA Method SW 8260) (1) Semivolatile Organic Compounds (EPA Method SW 8270) (1) Pesticides and PCBs (EPA Method SW 8081)	All sample locations were surveyed
8	Day tank is east of the Composite Facility and adjacent to the northern end of Site SS13-Landfarm	2 Soil Samples (AOC5-SB1 and SS1)	(2) Diesel Range Organics (Method AK102) (1) Volatile Organic Compounds (EPA Method SW 8260) (1) Semivolatile Organic Compounds (EPA Method SW 8270) (1) Pesticides and PCBs (EPA Method SW 8081)	All sample locations were surveyed
9	One day tank is located adjacent to the southwest corner of Bldg. 205	3 Soil Samples (AOC5-SB2, SB12, and SB13)	(2) Diesel Range Organics (Method AK102) (1) Volatile Organic Compounds (EPA Method SW 8260) (1) Semivolatile Organic Compounds (EPA Method SW 8270) (1) Pesticides and PCBs (EPA Method SW 8081)	All sample locations were surveyed



DIESEL RANGE ORGANICS
DRO (AK102) SUMMARY TABLE

Sample	Depth (ft)	DRO [mg/kg]
AOC5-SB1	2.5	8,900
AOC5-SB3	2.0	17,000
AOC5-SB4	2.0	9,400
AOC5-SB5	2.0	5,000
AOC5-SB8	1.0	14,000
AOC5-SB9	1.5	6,400
AOC5-SB10/11	1.0	17,000
AOC5-SB14	2.5	96
AOC5-SB15/16	3.5	2,000
AOC5-SB17	1.2	4,800
AOC5-SB18/19	2.5	330
AOC5-SB20	1.0	250
AOC5-SS1	-	120
AOC5-SB2	2.0	3,700
AOC5-SB6	1.0	12,000
AOC5-SB7	1.0	9,600
AOC5-SB11	2.5	23,000
AOC5-SB12	2.2	5,800
AOC5-SB13	2.5	190
AOC5-SB21	1.0	ND
AOC5-SB23/24	3.0	16,000
AOC5-SB25	3.5	140

Figure 7-48. Location of Sample Stations at AOC5-Small Day Tanks, 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

Section 4.5, Summary of Analytical Results; Tables 4-12 through 4-16. All sample analytical results for the 1994 RI are provided in Appendix L. All sample station locations were surveyed for horizontal and vertical coordinates (see Appendix C).

7.21.4 Remaining Site Concerns

Table 7-17 provides a summary of state and federal regulatory criteria (ARARs) and risk-based criteria exceeded in soil during the 1994 RI. State and federal ARARs established to guide the 1994 RI are at least as stringent as those criteria developed during previous investigations at Kotzebue LRRS (see Section 4.2, Applicable or Relevant and Appropriate Requirements).

Petroleum hydrocarbons in soil are the primary environmental concern associated with the small day tanks (AOC5) at Kotzebue LRRS. Diesel range organics detected in soil at each of the nine day tank locations revealed concentrations exceeding the ADEC soil target level of 1,000 mg/kg (see Table 7-48).

In support of the 1994 RI, a baseline risk assessment was conducted which indicated no significant risk to human health (i.e., $> 10^{-6}$ risk) for soil at AOC5 locations, based on 1994 RI results (USAF 1995b). A potential ecological risk (i.e., HQ > 1) for the dietary pathway at day tank locations 2, 3, 4, 5, and 8 was estimated based on the detection of total xylenes at 6.6 mg/kg, 14 mg/kg, 14 mg/kg, 35 mg/kg, and 19 mg/kg, respectively. Additionally, a potential ecological risk was estimated for the dietary pathway at tank locations 4, 5, 6, and 8 based on the detection of 2-methylnaphthalene at 57 mg/kg, 33 mg/kg, 14 mg/kg, and 27 mg/kg, respectively (see Table 4-17).

7.21.5 Site Recommendations

Formal USAF site identification is recommended for AOC5-Small Day Tanks, based on the detected concentrations of diesel range organics and total xylenes in soil. It is recommended that all day tanks no longer in use at Kotzebue LRRS be inspected to verify that no fuel remains in tanks or associated piping at the site. Fuel identified (if any) during inspection should be removed and properly contained to eliminate any potential for further release. To mitigate potential impacts to native tundra and eliminate potential human health or ecological concerns, it is recommended that gravel fill materials exceeding the ADEC soil target level of 1,000 mg/kg be excavated and removed from the site. The removal of contaminated fill materials above the ADEC soil target level will include soil containing total xylenes and the limited detection of chloroform. Onsite treatment of contaminated fill materials is recommended to

TABLE 7-17. SUMMARY OF IRP CLEANUP CRITERIA EXCEEDANCE AT AOC5-SMALL DAY TANKS, KOTZEBUE LRRS, ALASKA

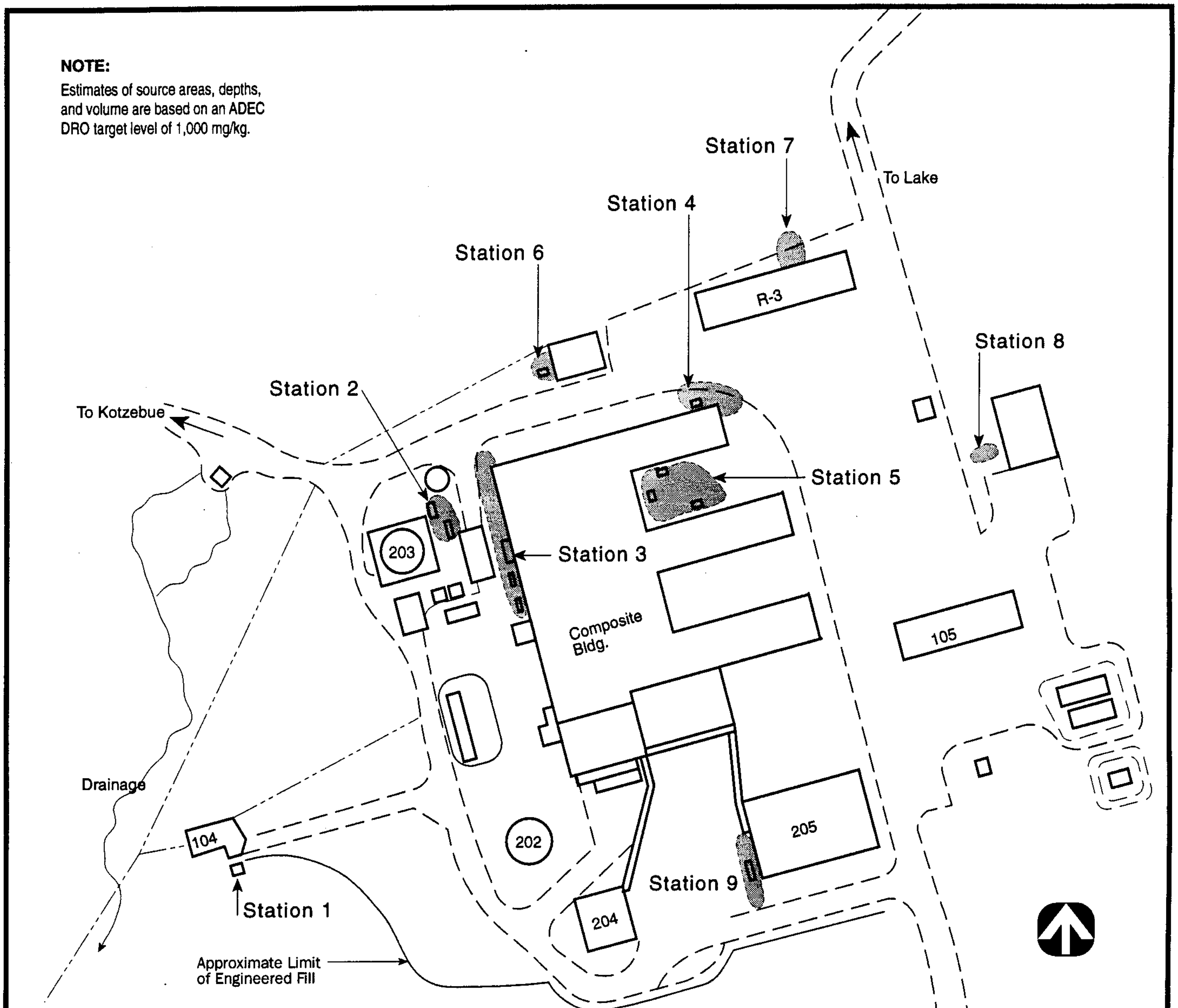
Day Tank Location Designation	ARAR[a] Exceedance				Risk Based Exceedance[c]									
					Human Health					Ecological				
	Media	Chemical of Concern	Sample Concentration	ARAR Criteria	Media	Pathway	Chemical of Concern	Sample Concen-tration	Health-Based Criteria	Media	Pathway	Chemical of Concern	Sample Concen-tration	Ecological Criteria
1	Soil	Diesel Range Organics	23,000 mg/kg	1,000 mg/kg[b]	No unacceptable risks were estimated					No unacceptable risks were estimated				
2	Soil	Diesel Range Organics	9,600 mg/kg	1,000 mg/kg[b]	No unacceptable risks were estimated					Soil	Dietary	Total xylene	6.6 m/gkg	2.6 mg/kg
3	Soil	Diesel Range Organics	12,000 mg/kg	1,000 mg/kg[b]	No unacceptable risks were estimated					Soil	Dietary	Total xylene	14 mg/kg	2.6 mg/kg
4	Soil	Diesel Range Organics	14,000 mg/kg	1,000 mg/kg[b]	No unacceptable risks were estimated					Soil	Dietary	Total xylene	14 mg/kg	2.6 mg/kg
												2-Methyl-naphthalene	57 mg/kg	6.6 mg/kg
5	Soil	Diesel Range Organics	17,000 mg/kg	1,000 mg/kg[b]	No unacceptable risks were estimated					Soil	Dietary	Total xylene	35 mg/kg	2.6 mg/kg
												2-Methyl-naphthalene	33 mg/kg	6.6 mg/kg
6	Soil	Diesel Range Organics	17,000 mg/kg	1,000 mg/kg[b]	No unacceptable risks were estimated					Soil	Dietary	2-Methyl-naphthalene	14 mg/kg	6.6 mg/kg
7	Soil	Diesel Range Organics	6,400 mg/kg	1,000 mg/kg[b]	No unacceptable risks were estimated					No unacceptable risks were estimated				
8	Soil	Diesel Range Organics	8,900 mg/kg	1,000 mg/kg[b]	No unacceptable risks were estimated					Soil	Dietary	Total xylene	19 mg/kg	2.6 mg/kg
												2-Methyl-naphthalene	27 mg/kg	6.6 mg/kg
9	Soil	Diesel Range Organics	5,800 mg/kg	1,000 mg/kg[b]	No unacceptable risks were estimated					No unacceptable risks were estimated				

[a] Applicable or relevant and appropriate requirements.

[b] Alaska Department of Environmental Conservation; Petroleum hydrocarbon target level of 1,000 mg/kg for soils at Kotzebue LRRS.

[c] Ecological and human health risk based criteria established using 1994 Remedial Investigation results (USAF 1995b).

reduce diesel range organics, total xylenes, and chloroform to acceptable levels for the onsite disposal of treated soil. The estimated 804 cubic yards of contaminated material at or above the 1,000 mg/kg ADEC soil target level are located in an area 35 feet by 20 feet with a depth of 3 feet for Station 2; an area 140 feet by 12 feet with a depth of 3 feet for Station 3; an area 42 ft by 20 feet with a depth of 3 feet for Station 4; an area 60 feet by 40 feet with a depth of 3 feet for Station 5; an area 20 feet by 15 feet with a depth of 3 feet for Station 6; an area 20 feet by 15 feet with a depth of 3 feet for Station 7; an area 20 feet by 12 feet with a depth of 3 feet for Station 8; and an area 50 feet by 15 feet with a depth of 3 feet for Station 9 (Figure 7-49). The day tank located adjacent to the septic holding tank (Station #1) is within Site SS12-Spills No. 2 and 3; therefore, native soil adjacent to the tank is considered in the evaluation of Site SS12. The day tank located across the facility access road north of the Composite Facility (Station #6) is located above native tundra; as such, limited action is recommended for native soil impacted by this day tank through natural attenuation processes.



AOC5-Small Day Tanks

Source Characterization

	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7	Station 8	Station 9
Estimated Source Area (ft^2)	ND	35 x 20	140 x 12	42 x 20	60 x 40	20 x 15	20 x 15	20 x 12	50 x 15
Average Estimated Source Depth (ft)	ND	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Estimated Source Volume (yd^3)	ND	78	187	94	267	34	34	27	83
Detected Contaminants	Diesel Range Organics								
Release Data Type: Timing: Volume:	Suspected Diesel Fuel Unknown Unknown								

ND = Not Determined. Station 1 located within Site SS12-Spills No. 2 and 3.

Figure 7-49. DRO Contaminant Source Characterization at AOC5-Small Day Tanks, 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

7.22 AOC7-STEEL PILINGS

7.22.1 Summary of Site Status

AOC7-Steel Pilings represents the location of several steel pilings located on the east side of the facility access road, southeast of the Composite Facility. Site characterization information indicates that there are no environmental concerns associated with AOC7-Steel Pilings. AOC7 is not formally identified as a site at Kotzebue LRRS; therefore, no closure documents are required.

7.22.2 Site Description

AOC7 represents the location of several steel pilings located on the east side of the facility access road, southeast of the Composite Facility (Figure 7-50). Buildings identified during a review of historical aerial photographs suggested that this area was a former construction camp established during the construction of the radar facility. The site has been completely revegetated and reveals relatively poor drainage, which is directed to the northeast. Permafrost was encountered at relatively shallow depths (e.g., 1 foot below ground surface) in native soils during the 1994 RI.

7.22.3 IRP Investigation Summary

During a 1993 site survey, several erect steel pilings were identified southeast of the Composite Facility (see Figure 7-50). A review of historical aerial photographs showed buildings that suggested this area was a former construction camp. The area had not been characterized during previous investigations and the USAF identified the Steel Pilings as an area of concern (AOC7) for investigation during the 1994 RI.

During the 1994 RI, AOC7 was characterized by visual inspection and soil sample collection. No evidence of site contamination was observed based on visual inspection of the site. A total of three shallow subsoil samples were collected from low lying areas in native tundra at the site. Figure 7-51 shows the sample station locations at AOC7. All samples were analyzed for diesel range organics (Method AK102), volatile organic compounds (EPA Method SW8260), semivolatile compounds (EPA Method SW 8270), and pesticides and PCBs (EPA Method SW8081). In addition, two samples were submitted for metals (EPA Method 6010 series) analysis. A summary of maximum detected concentrations identified at Site AOC7 is provided in Section 4.5, Summary of Analytical Results; Tables 4-12 through 4-16. All sample analytical results for the 1994 RI are provided in Appendix L. All sample station locations were surveyed for horizontal and vertical coordinates (see Appendix C).

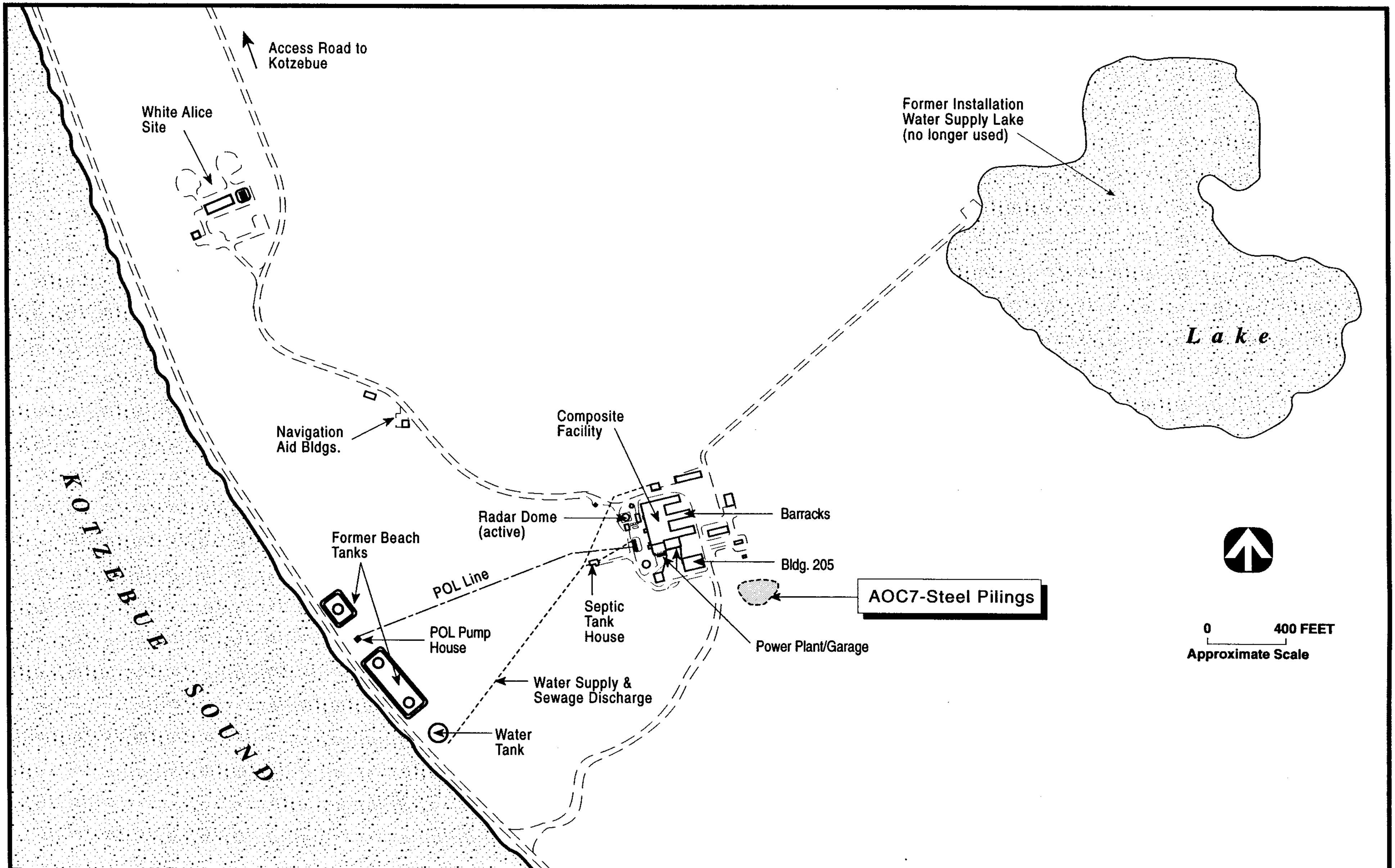
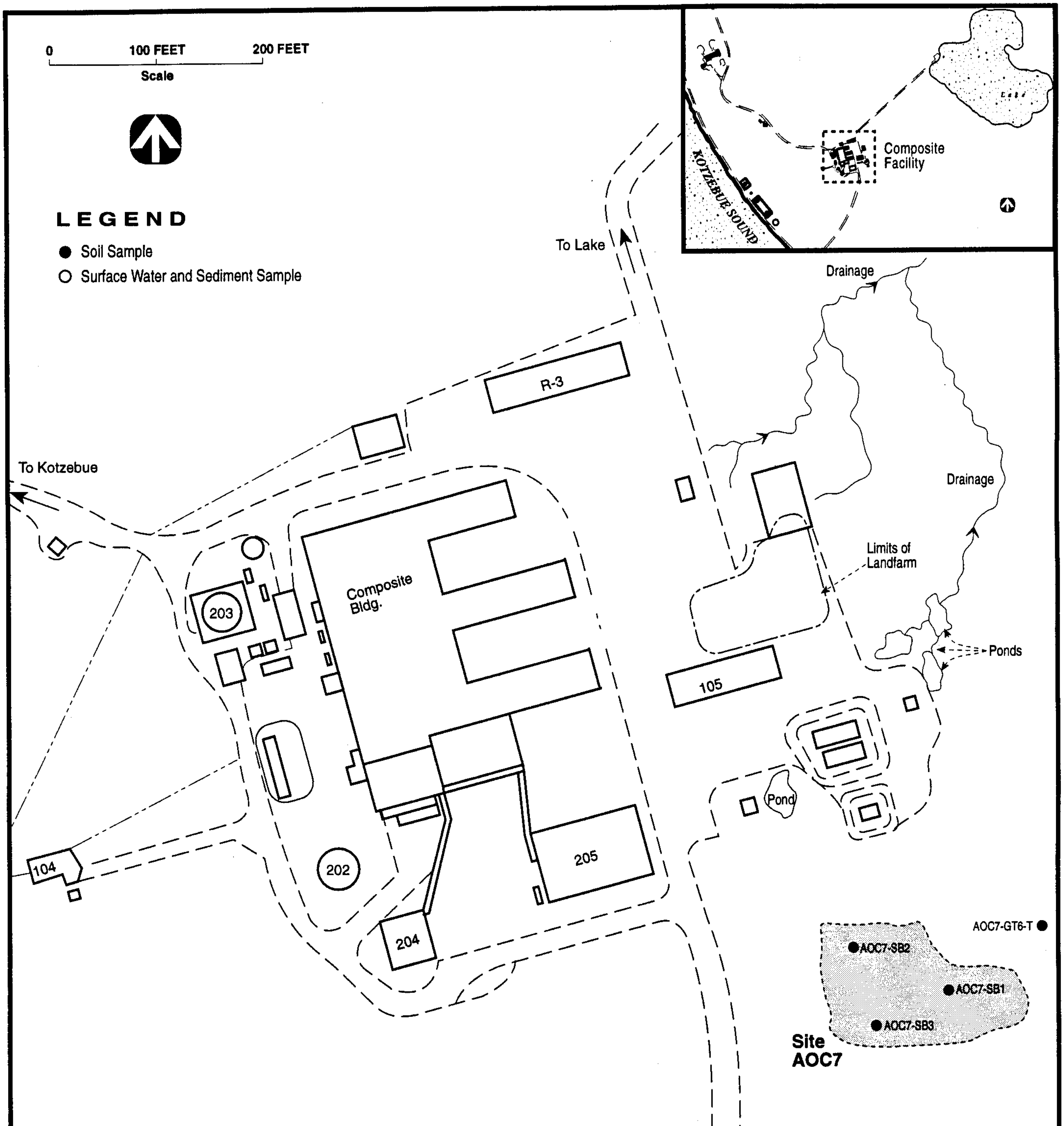


Figure 7-50. Location of AOC7-Steel Pilings, Kotzebue LRRS, Alaska.



DIESEL RANGE ORGANICS (Method AK102) SUMMARY TABLE		
Sample	Depth (ft)	DRO [mg/kg]
AOC7-SB1	1.0	1.2
AOC7-SB2	1.0	130
AOC7-SB3	1.0	130

Figure 7-51. Location of Sample Stations at AOC7-Steel Pilings, 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

A single subsoil sample (AOC7-GT6-T) was collected from native tundra for analysis of geotechnical parameters, including permeability (ASTM Method D5084) and grain-size distribution (ASTM Methods C136 and D442), and for total organic carbon (EPA Method 9060). Geotechnical sample results are discussed in Section 4.6.4, Geotechnical Sample Results, and are provided in Appendix E.

7.22.4 Remaining Site Concerns

State and federal ARARs established to guide the 1994 RI are discussed in Section 4.2, Applicable or Relevant and Appropriate Requirements. No exceedance of ARARs and no significant ecological risks were identified for soils at AOC7, based on 1994 RI results (USAF 1995b). The health risk assessment indicated a potential risk (i.e., $>10^{-6}$ risk) for soil ingestion (1.99E-6) and inhalation of airborne dust (2.14E-6) pathways based on the detection of arsenic in Sample AOC7-SB1 at 5 mg/kg. Although site soil samples exceed health based threshold criteria for arsenic (i.e., 4.74 mg/kg for ingestion and 4.61 mg/kg for inhalation), their concentrations are less than the arithmetic mean concentration of arsenic measured in background soil samples (i.e., 27 mg/kg). No known sources of arsenic are identified for Site AOC7 and the detection of arsenic in background location indicate this element is naturally occurring. The average concentration of arsenic in natural soils is reportedly 5 mg/kg, but can range from 1 mg/kg to 50 mg/kg (EPA 1983).

7.22.5 Site Recommendations

Site characterization information indicates that there are no environmental concerns associated with AOC7-Steel Pilings. AOC7 is not formally identified as a site at Kotzebue LRRS; therefore, no closure documents are required.

7.23 AOC8-WHITE ALICE GARAGE

7.23.1 Summary of Site Status

AOC8-White Alice Garage is the location of a garage facility located at the White Alice Site which reportedly was used for storing and servicing vehicles. Detected concentrations of diesel range organics (up to 3,500 mg/kg), remaining in fill materials is the primary environmental concern at the site. To mitigate potential impacts to native tundra and eliminate any potential human health concerns, an interim remedial action is recommended so that gravel fill materials exceeding the ADEC soil target level of 1,000 mg/kg be excavated and removed from the site. The removal of contaminated fill materials above the ADEC soil target level will include soil containing Aroclor 1260 (up to 8.4 mg/kg). Onsite treatment of contaminated fill materials is recommended to reduce petroleum hydrocarbons to acceptable levels for the onsite disposal of treated soil.

7.23.2 Site Description

AOC8 is the location of a garage facility located at the White Alice Site (Figure 7-52). The White Alice Garage was reportedly used for storing and servicing facility vehicles (USAF 1985). The garage consists of a one-room, two-story building with insulated walls and a concrete floor. No plumbing or floor drains were identified during inspection of the garage in 1994. A single day tank is located adjacent to the northeast corner of the garage facility.

The garage area is situated on a raised 4 to 5-foot thick gravel pad located at an approximate elevation of 125 feet above sea level. The site exhibits moderate drainage, which is directed to the west along the tundra hill sloping toward Kotzebue Sound. Ponded surface water which drains the site locally is located immediately to the north of the garage facility (see Figure 7-52).

7.23.3 IRP Investigation Summary

In 1993, a site survey of Kotzebue LRRS was conducted to evaluate current site conditions, identify potential areas of concern, and obtain information necessary to prepare RI/FS scoping documents for the 1994 IRP field activities. During the site survey, the White Alice Garage and surrounding area was selected as an area of concern (AOC8-White Alice Garage) for investigation during the 1994 RI based on its past operation history and lack of any previous site characterization information. AOC8 was

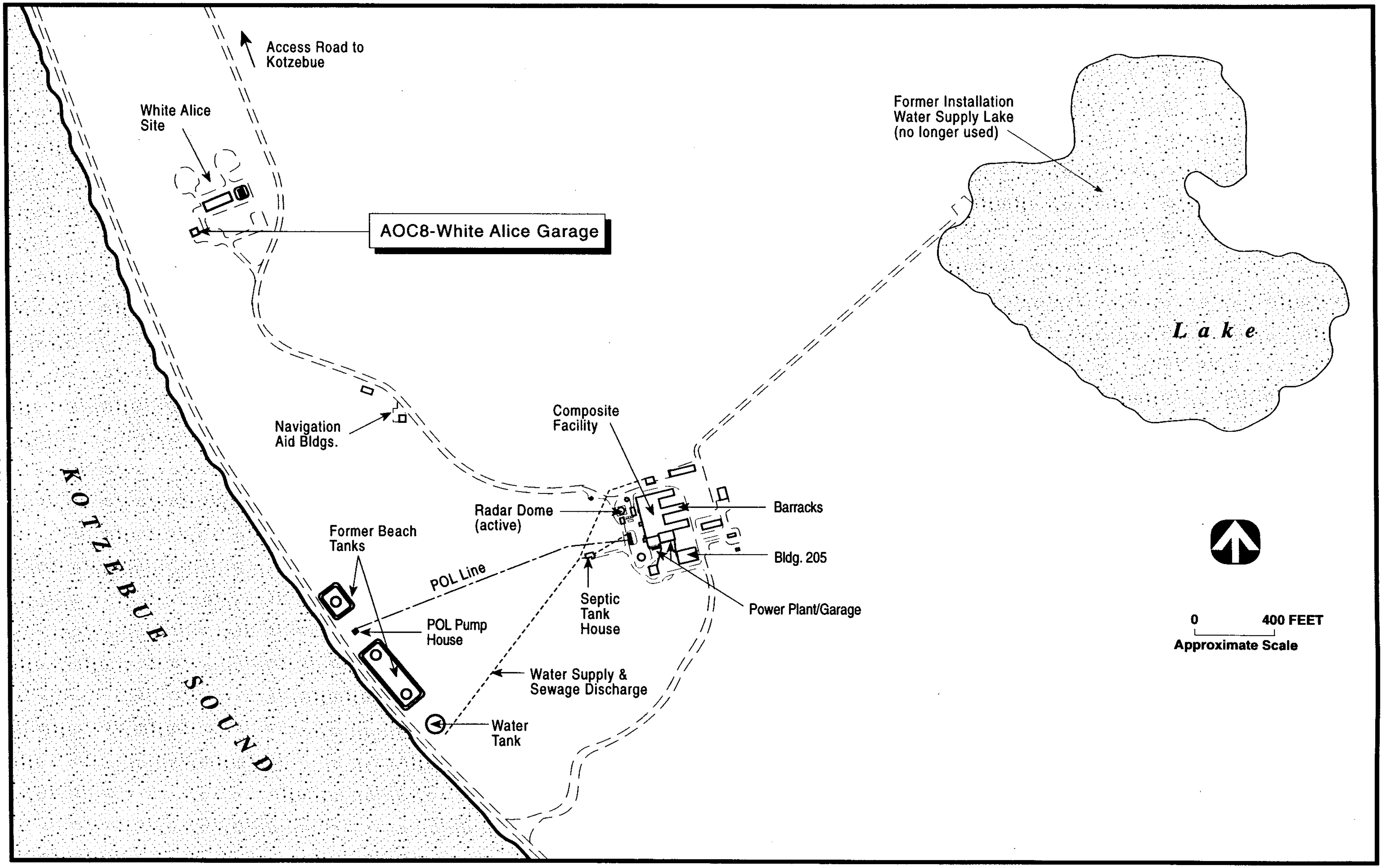


Figure 7-52. Location of AOC8-White Alice Garage, Kotzebue LRRS, Alaska.

characterized during the 1994 RI, including an inspection of the garage facility and surrounding area, and collection of soil samples.

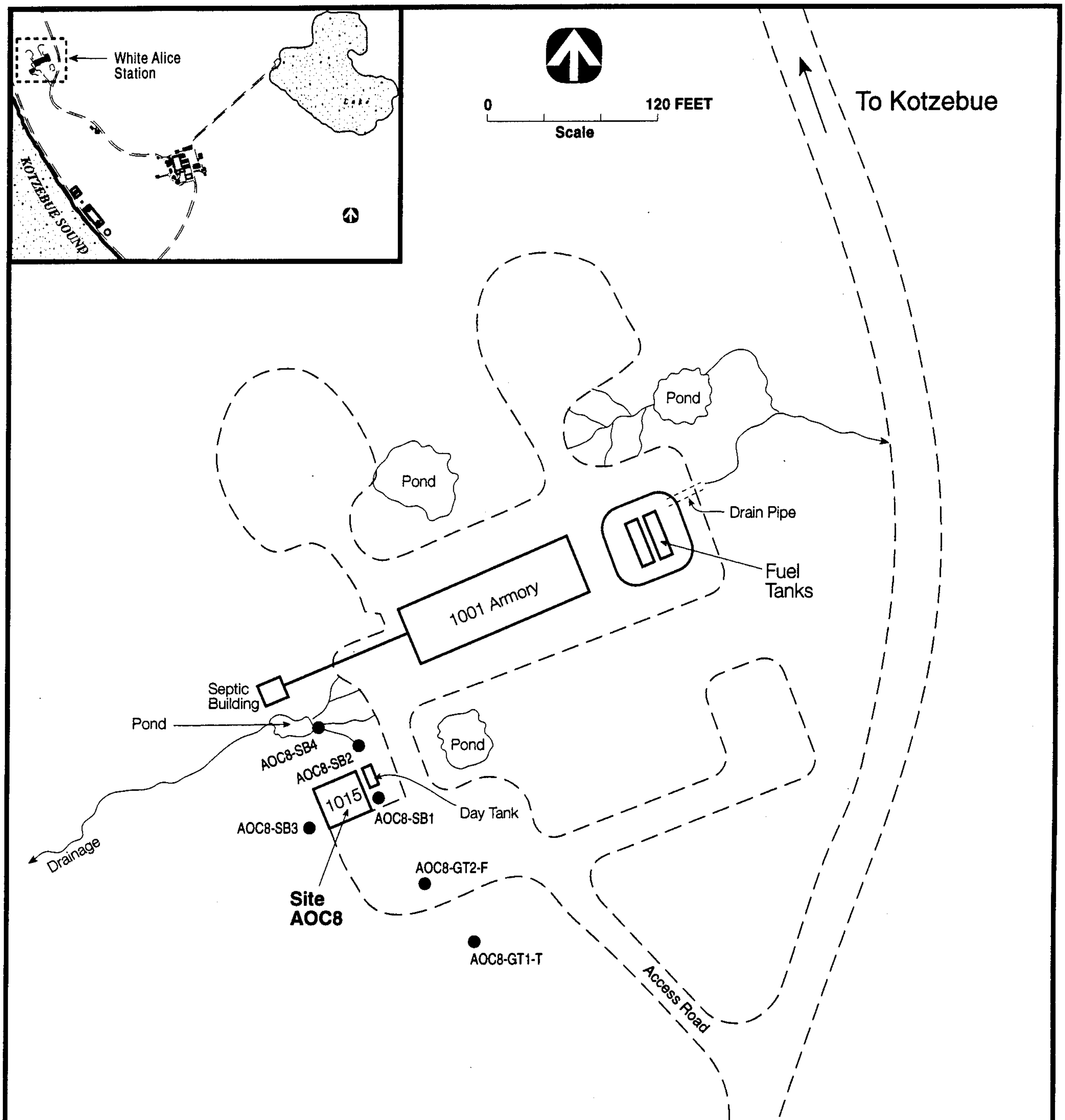
7.23.3.1 Garage Inspection. On 20 June 1994, an inspection of the garage interior was conducted for indications of past operations involving the potential use or storage of hazardous substances. The White Alice Garage consists of a one-room, two-story building with insulated walls and a concrete floor. The northwest corner of the room is partitioned into a small office with a separate exit. The inspection of this structure identified an absence of any plumbing or floor drains. This building is not presently secure and it appears that local people or Air Force contractors have used the structure to repair snow machines in the past. There are no indications of past or present use of the building to store fuel or hazardous materials. No petroleum odors or stained soil were observed under or around this structure.

7.23.3.2 Soil Sampling. A total of four shallow subsoil samples were collected for analysis, including gasoline range organics (Method AK101), diesel range organics (Method AK102), volatile organic compounds (EPA Method SW8260), semivolatile compounds (EPA Method SW 8270), and pesticides and PCBs (EPA Method SW8081). In addition, two samples were submitted for metals (EPA Method 6010 series) analysis. Figure 7-53 shows the sample locations at AOC8. A summary of maximum detected concentrations identified at Site AOC2 is provided in Section 4.5, Summary of Analytical Results; Tables 4-12 through 4-16. All sample analytical results for the 1994 RI are provided in Appendix L. All sample station locations were surveyed for horizontal and vertical coordinates (see Appendix C).

Two subsoil samples were collected for geotechnical parameters, including permeability (ASTM Method D5084) and grain-size distribution (ASTM Methods C136 and D442), and for total organic carbon (EPA Method 9060). Sample AOC8-GT1-T was collected from native tundra and Sample AOC8-GT2-F was collected from engineered fill material to estimate critical parameters regarding contaminant transport in primary site lithologies (see Figure 7-53). Geotechnical sample results are discussed in Section 4.6.4, Geotechnical Sample Results, and provided in Appendix E.

7.23.4 Remaining Site Concerns

State and federal ARARs established to guide the 1994 RI are discussed in Section 4.2, Applicable or Relevant and Appropriate Requirements. Petroleum hydrocarbon contamination detected in soil is the primary environmental concern at AOC8. Diesel range organics were detected in two of four soil



DIESEL RANGE ORGANICS (Method AK102) SUMMARY TABLE

Sample	Depth (ft)	DRO [mg/kg]
AOC8-SB1	1.5	150
AOC8-SB2	1.5	1,100
AOC8-SB3	3.5	3.3
AOC8-SB4	1.0	3,500

Figure 7-53. Location of Sample Stations at AOC8-White Alice Tanks, 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

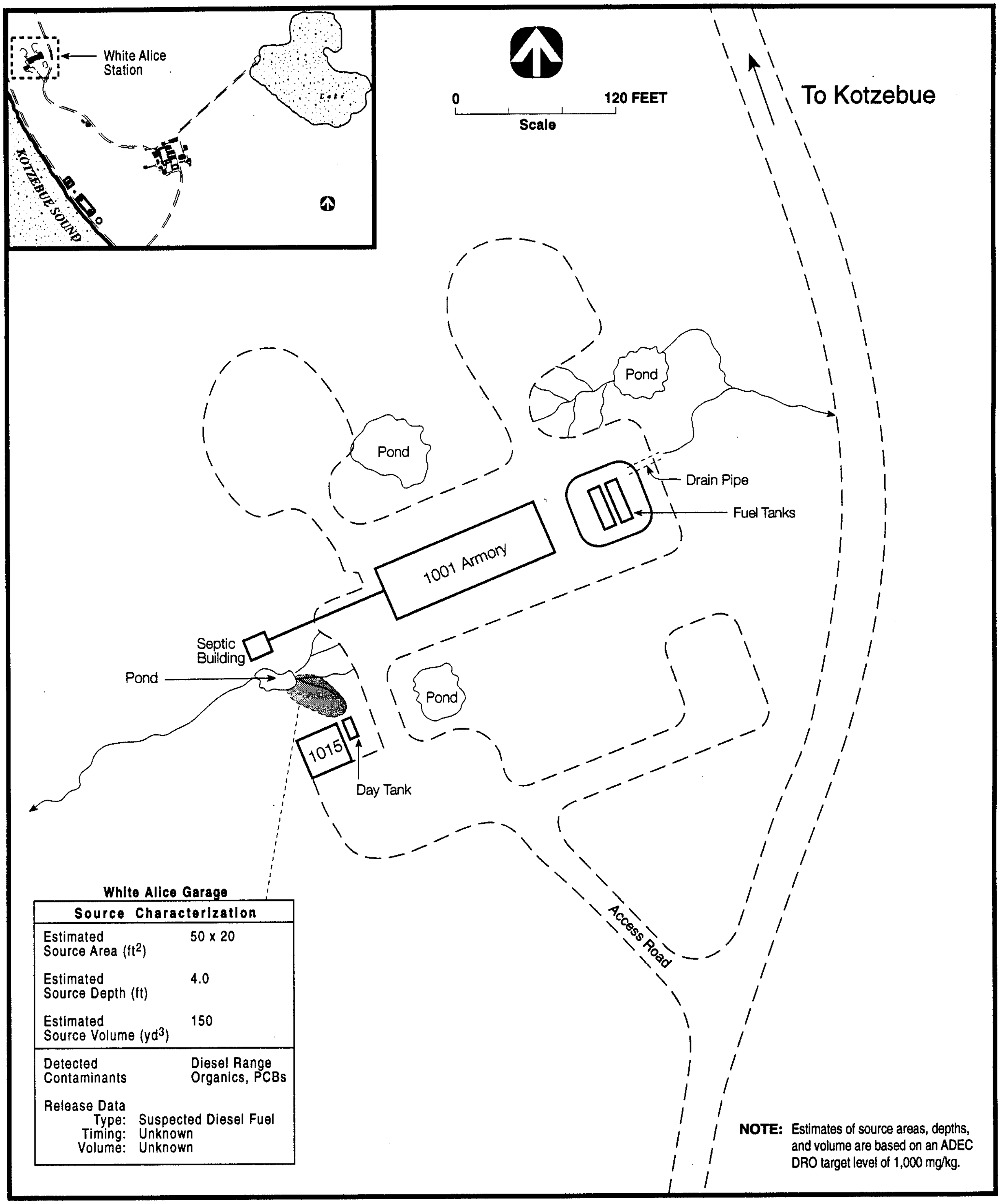
samples which exceed the ADEC soil target level of 1,000 mg/kg, including Sample AOC8-SB2 at 1,100 mg/kg and Sample AOC8-SB4 at 3,500 mg/kg. Gasoline range organics were detected at relatively low concentrations, with a maximum concentration of 120 mg/kg reported in Sample AOC8-SB2 (see Figure 7-52).

In support of the 1994 RI, a baseline risk assessment was conducted. No significant ecological risk was identified at AOC8 based on the 1994 RI results (USAF 1995b). The health risk assessment indicated a potential risk to human health (i.e., $>10^{-6}$ risk) for both soil ingestion (1.95E-6) and dermal contact (1.63E-5) pathways, based on the detection of PCB Aroclor 1260 in all four samples: Sample AOC8-SB1 at 0.35 mg/kg, Sample AOC8-SB2 at 0.54 mg/kg, Sample AOC8-SB3 at 1.6 mg/kg, and Sample AOC8-SB4 at 8.4 mg/kg. The baseline risk assessment incorporated a number of conservative assumptions, including the frequency at which recreational and subsistence users may be exposed to contaminants (e.g., assumes exposure every day during the four summer months when contact with contaminants is not limited by frozen ground and/or snow cover). Based on the conservative nature of the baseline risk assessment and the fact that the concentration of Aroclor 1260 is below the U.S. EPA Region 10 PCB cleanup criteria established at 10 mg/kg for soil at Kotzebue LRRS (EPA 1987), no remedial action concerning PCBs in soils is considered warranted at the site. The health risk assessment indicated a potential risk to human health for both soil ingestion (2.11E-6) and inhalation of airborne dust (2.14E-6) pathways based on the detection of arsenic in Samples AOC8-SB1 at 10 mg/kg and AOC8-SB3 at 6 mg/kg. Although site soil samples exceed health based threshold criteria for arsenic (i.e., 4.74 mg/kg for ingestion and 4.61 mg/kg for inhalation), their concentrations are less than the arithmetic mean concentration of arsenic measured in background soil samples (i.e., 27 mg/kg). No known sources of arsenic are identified for Site AOC8 and the detection of arsenic in background locations indicate this element is naturally occurring. The average concentration of arsenic in natural soils is reportedly 5 mg/kg, but can range from 1 mg/kg to 50 mg/kg (EPA 1983).

7.23.5 Site Recommendations

Detected concentrations of diesel range organics (up to 3,500 mg/kg) remaining in fill material is the primary environmental concern at the site. To mitigate potential impacts to native tundra and eliminate any potential human health concerns, an interim remedial action is recommended so that gravel fill materials exceeding the ADEC soil target level of 1,000 mg/kg be excavated and removed from the site. The removal of contaminated fill materials above the ADEC soil target level will include soil containing

Aroclor 1260 (up to 8.4 mg/kg). Onsite treatment of contaminated fill materials is recommended to reduce petroleum hydrocarbons to acceptable levels for the onsite disposal of treated soil. The estimated volume of 150 cubic yards of contaminated material at or above the 1,000 mg/kg ADEC soil target level are located in an area 50 feet by 20 feet, with an average estimated depth of 4 feet (Figure 7-54).



Source Characterization	
Estimated Source Area (ft^2)	50 x 20
Estimated Source Depth (ft)	4.0
Estimated Source Volume (yd^3)	150
Detected Contaminants	Diesel Range Organics, PCBs
Release Data	
Type:	Suspected Diesel Fuel
Timing:	Unknown
Volume:	Unknown

Figure 7-54. DRO Contaminant Source Characterization at AOC8-White Alice Tanks, 1994 Remedial Investigation, Kotzebue LRRS, Alaska.

7.24 AOC10-SEPTIC HOLDING TANK

7.24.1 Summary of Site Status

Primary treatment of domestic sewage and wastewater at Kotzebue LRRS was provided by a single above-ground septic tank located west of the Composite Facility. The septic tank was identified as an area of concern (AOC10-Septic Holding Tank) for investigation during the 1994 RI because tank effluent was historically discharged into Kotzebue Sound via an outfall line. A sludge sample collected from the base of the septic tank revealed concentrations of volatile and semivolatile compounds, pesticides and PCBs, and metals which, if released to the environment, could exceed established regulatory and/or risk-based criteria established for Kotzebue LRRS. Further site assessment is recommended to determine if historical effluent discharge from the septic tank has impacted Kotzebue Sound at or near the outfall location. Removal and/or treatment of sludge material remaining within the septic holding tank is recommended.

7.24.2 Site Description

Site AOC10 is located approximately 300 feet west of the Composite Facility (Figure 7-55). The site provided the primary treatment for domestic sewage and wastewater at Kotzebue LRRS. The septic tank is housed within a small, raised wood-framed building (Building 104). The capacity of the septic holding tank was not determined during the 1994 RI due to its unaccessibility within Building 104. The facility sink and floor drain piping connect to a main sewer line which discharged directly into the septic tank. Septic tank effluent was discharged to Kotzebue Sound via an outfall line (see Figure 7-55).

7.24.3 IRP Investigation Summary

In 1994, the USAF conducted an RI at Kotzebue LRRS which included an inspection and sampling at Site AOC10. One sludge sample was collected from within the septic tank and was analyzed for diesel range organics (Method AK 102), residual range organics (Method AK102 extended), volatile organic compounds (Method SW 8260), semivolatile organic compounds (Method SW 8270), pesticides and PCBs (Method SW 8081), and total metals (Method SW 6010 series). A summary of maximum detected concentrations identified at Site AOC10 during the 1994 RI is provided in Section 4.5, Summary of Analytical Results; Tables 4-12 through 4-16. All sample analytical results for the 1994 RI are provided in Appendix L.

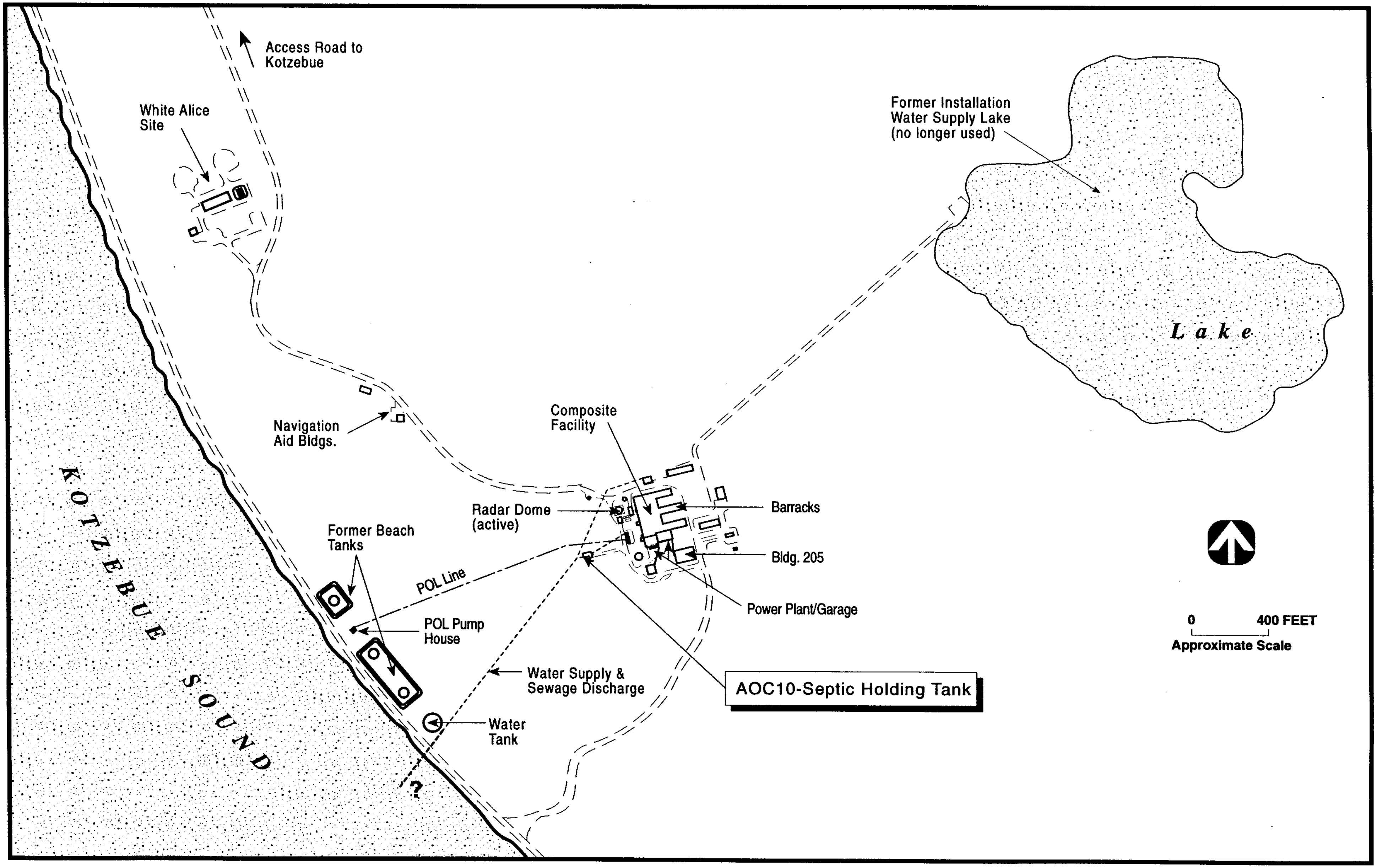


Figure 7-55. Location of AOC10-Septic Holding Tank, Kotzebue LRRS, Alaska.

During the investigation at Site AOC10, sewer lines were inspected, including discharges from sink and floor drains at the main power plant and garage facility at Kotzebue LRRS. The sewer line discharging from sink and floor drains is exposed above ground for its entire length, except where it crosses under the access road (gravel fill) at the western boundary of the Composite Facility. Wastewater entering the sewer line from within the garage area flows north where it connects to the main sewer line of the Composite Facility, approximately 70 feet north of the garage. The main sewer line travels west under the Composite Facility and discharges into the septic holding tank. No breaks or signs of past leaking of the sewer lines were observed upgradient of the septic tank; therefore, no soil samples were collected along these sections of the sewer piping. The sewer discharge pipe from the septic building to Kotzebue Sound was inspected and found to be broken in two locations. In addition, large portions of the effluent sewer line had fallen off their supports. However, no indication of stained soils or stressed vegetation was observed in the vicinity of the broken sections of pipe and no soil samples were collected based on inspection observations.

7.24.4 Remaining Site Concerns

A sludge sample collected from within the septic tank revealed concentrations of volatile and semivolatile compounds, pesticides and PCBs, and metals, which if released to the environment, could exceed established regulatory and/or risk-based criteria established for Kotzebue LRRS. A summary of detected concentrations in septic tank sludge is provided in Table 7-18.

TABLE 7-18. SUMMARY OF DETECTED CONCENTRATIONS IN SEPTIC TANK SLUDGE

Analytical Variable	Analyte	Detected Concentrations (mg/kg)
Volatile Organic Compounds	Toluene Total Xylene	24 11
Semivolatile Organic Compounds	Phenol 1,4-Dichlorobenzene 4-Methylphenol 4-Chloroaniline	69 46 82 9.0
Pesticides and PCBs	Aroclor 1254 Aroclor 1260	4.2 2.2
Diesel Range Organics	DROs	8,600
Total Metals	Cadmium Chromium Lead Mercury Zinc	30 130 1,300 4.5 12,000

The sludge contained within the septic tank may tend to concentrate the contaminants which were introduced and processed through the treatment system over time. As such, historical effluent discharge to Kotzebue Sound may not necessarily be expected at the concentrations identified above. No evidence of breaks or leaks were identified at Site AOC10 or from sewer lines located upgradient of the septic tank. Two breaks in the effluent piping leading from the septic tank to Kotzebue Sound were identified during inspection; however, no signs of environmental contamination were observed at these locations. No investigation has previously been conducted to assess the potential for contamination at the outfall location in Kotzebue Sound.

7.24.5 Site Recommendation

It is recommended that removal and/or treatment of the contaminated sludge material remaining within the septic holding tank be conducted to eliminate the potential for release to the environment. It is also recommended that further site assessment be conducted to determine if historical effluent discharge from the septic tank has adversely impacted Kotzebue Sound at or near the outfall location. Further site assessment should include identification of the septic tank outfall (i.e., effluent pipe discharge point) location in Kotzebue Sound and sediment sample collection at this location. It is recommended that sediments be characterized for those compounds detected in septic tank sludge including volatile organics, semivolatile organics, PCBs and pesticides, diesel range organic compounds, and total metals.

8.0 STATUS OF COMMUNITY INVOLVEMENT

A primary objective of the USAF is to provide appropriate project information and opportunities for community involvement throughout the environmental investigation and cleanup process at Kotzebue LRRS. The USAF has utilized a variety of communication tools to provide information, encourage public participation, and respond to community concerns including:

- Personal interviews with members of the Kotzebue Community were conducted to document concerns, questions, and ideas regarding environmental conditions at Kotzebue LRRS.

- A Community Relations Plan (CRP) was developed during the planning stage of the RI/FS to provide accurate, straightforward, and up-to-date information about all phases of cleanup activities at Kotzebue LRRS to public officials, commercial interests, the community, and other interested parties (USAF 1994e). This includes information about the IRP investigation and cleanup process, and the various roles of the USAF, other government agencies, and other interested groups or individuals participating in the IRP Process.

- An information repository is being established at the Kotzebue City Hall to serve as a central point where members of the community can review information regarding the site and varies investigation and cleanup activities. Information about the IRP process, federal requirements, technical documents, fact sheets, news releases, news articles and other informational materials, and a copy of the administrative record, will be maintained in the repository.

- During the 1994 remedial investigation, news letters and fact sheets were circulated and radio and television messages were provided to inform the community of activities in progress at Kotzebue LRRS.

Site investigation activities and interim remedial actions conducted at Kotzebue LRRS were supported by local companies and personnel. Field teams were stationed at Drake's Camp, and heavy equipment and operators form Drake's Construction were employed at the site during the 1994 Field season. Supplies and equipment were purchased from local suppliers.

The City of Kotzebue has teamed with the USAF and other agencies to establish a Restoration Advisory Board (RAB). The concept of forming a RAB was initiated by the USAF in order to involve the local communities in the process of environmental awareness and prioritizing cleanup. The board will serve as a forum for discussion and information exchange between the community and the federal/state agencies who are guiding the restoration of the Kotzebue LRRS. The responsibilities of the RAB include addressing such issues as cleanup goals, setting priorities, reviewing plans and documents, and conducting regular meetings that are open to the public. The RAB complements other community involvement initiatives that have been established, and provides an additional means of information gathering and exchange.

Co-chaired by a community representative and a USAF representative, the RAB may be comprised of members from the local community, the USAF, the EPA regional office, State of Alaska, local Kotzebue government, and native organizations. The City of Kotzebue came out in support of the RAB through resolution No. 95-191, announced by the City Council on 15 December 1994. The Kotzebue Indian Reorganization Act resolved to support the RAB effort and the Board of Directors issued a proclamation promoting the effort.

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